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EXHIBITING A VIEW OF

THE PROGRESS OF DISCOVERY IN NATURAL PHILOSOPHY,
CHEMISTRY, NATURAL HISTORY, PRACTICAL MECHANICS,
GEOGRAPHY, NAVIGATION, STATISTICS, AND THE FINE
AND USEFUL ARTS,

FOR

JANUARY......APRIL 1820.

CONDUCTED BY

DR BREWSTER AND PROFESSOR JAMESON.

TO BE CONTINUED QUARTERLY.

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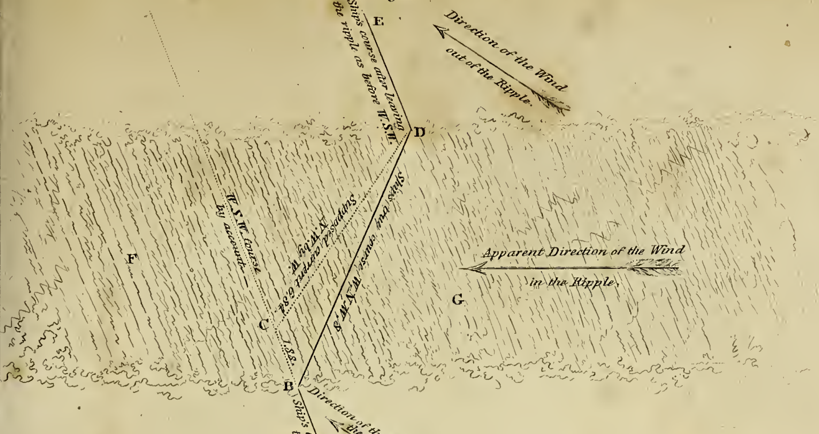

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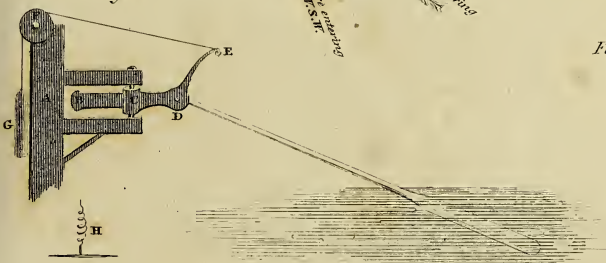

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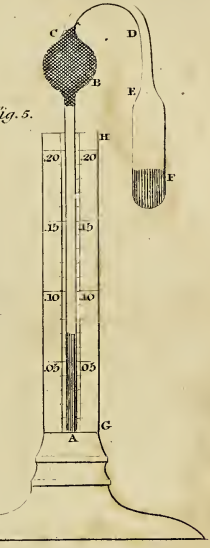

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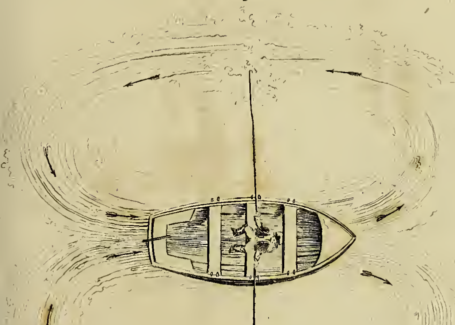

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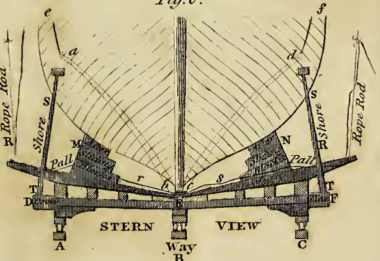

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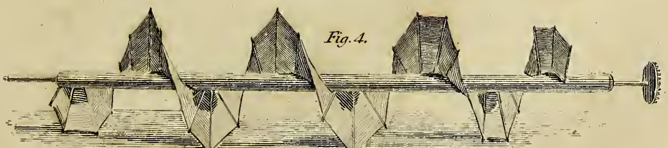

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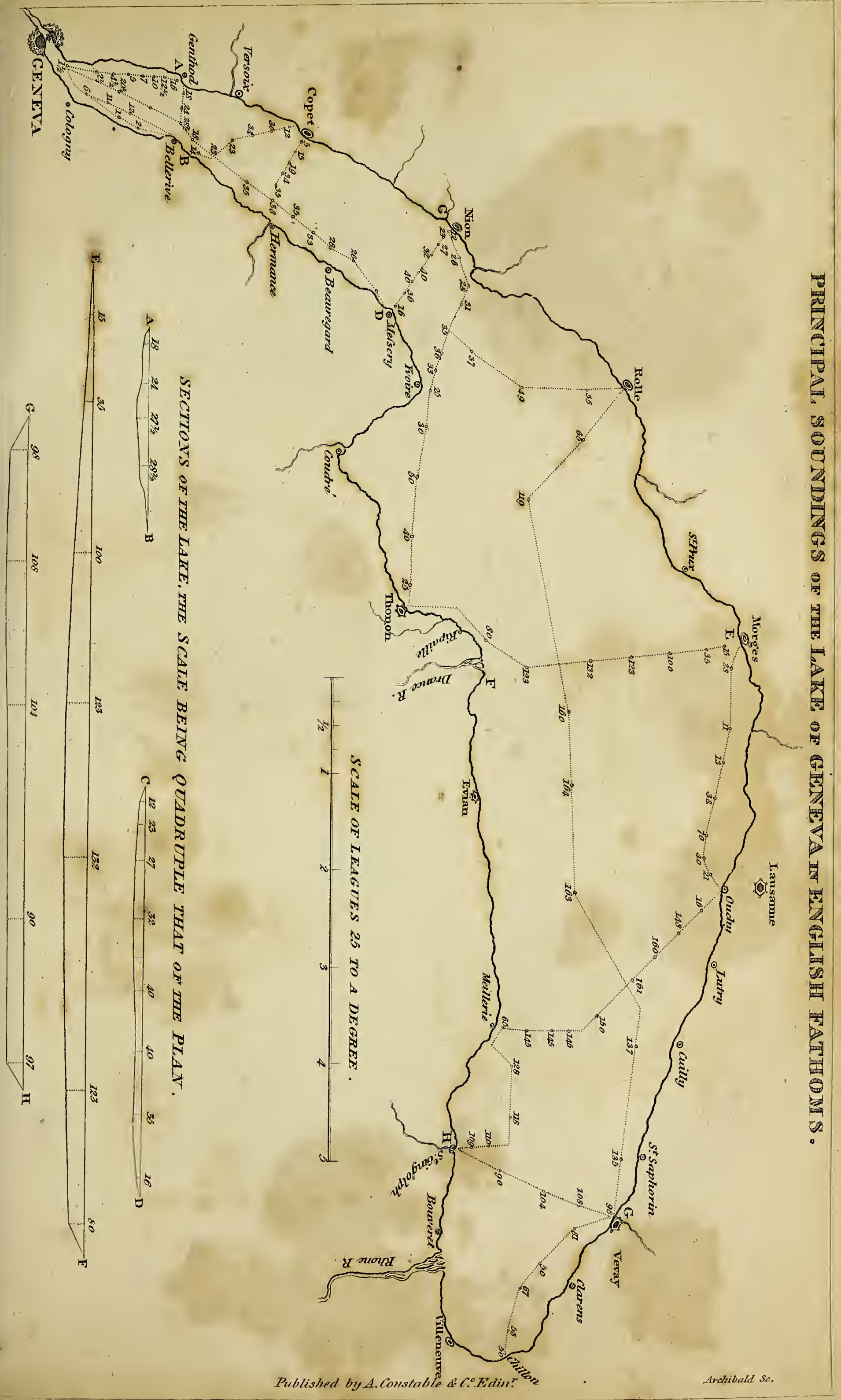

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SECTIONS OF THE LAKE, THE SCALE BEING QUADRUPLE THAT OF THE PLAN.

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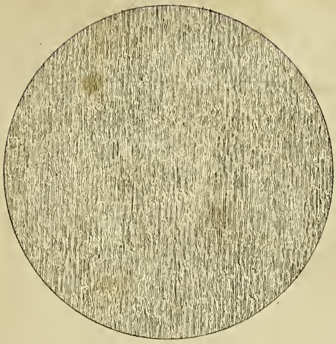

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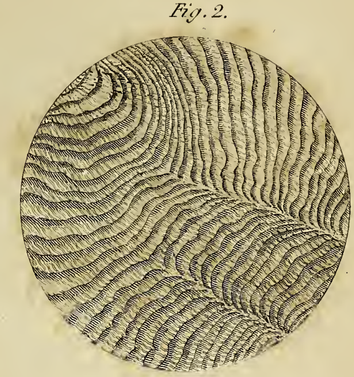

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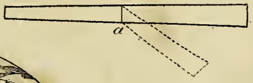

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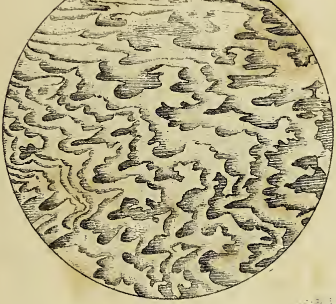

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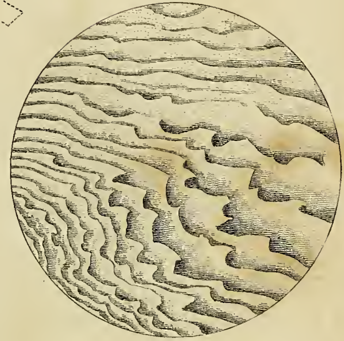

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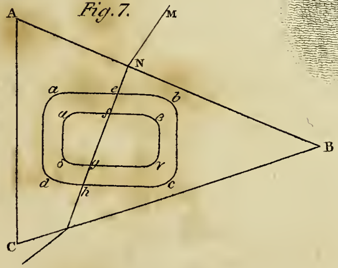

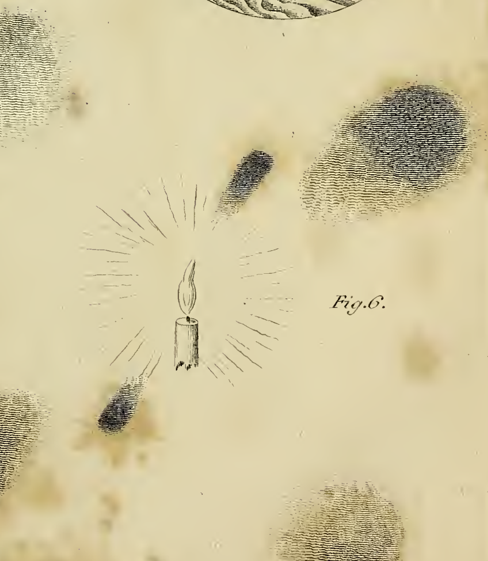

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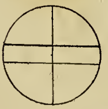

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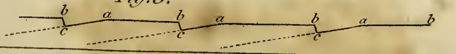

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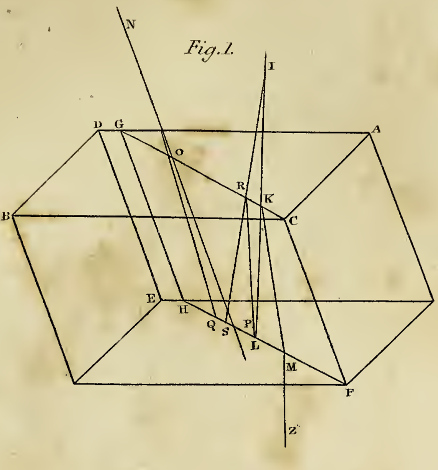

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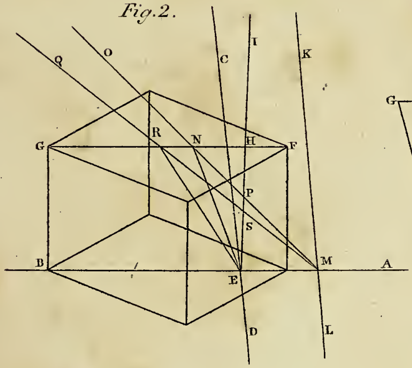

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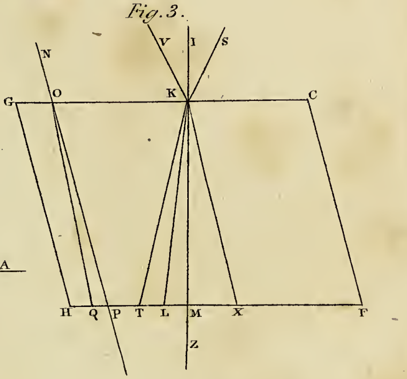

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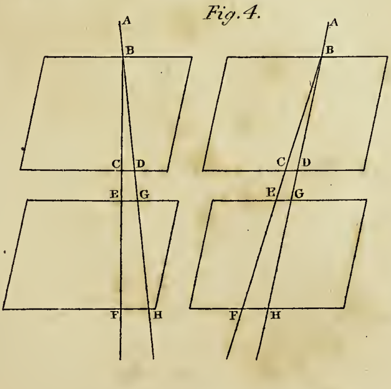

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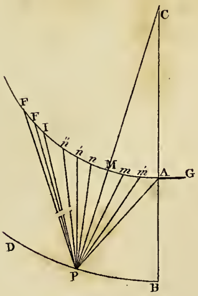

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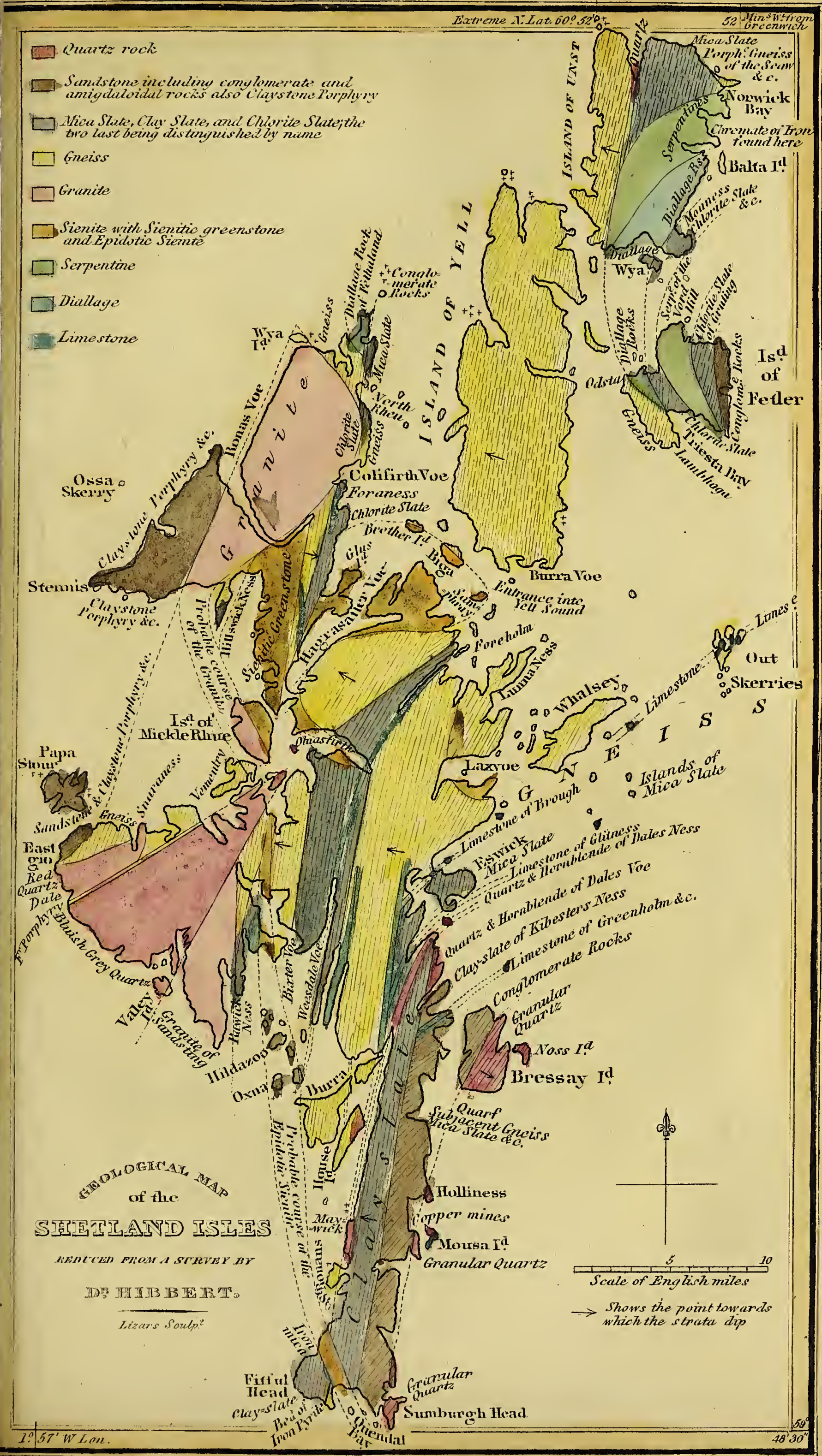
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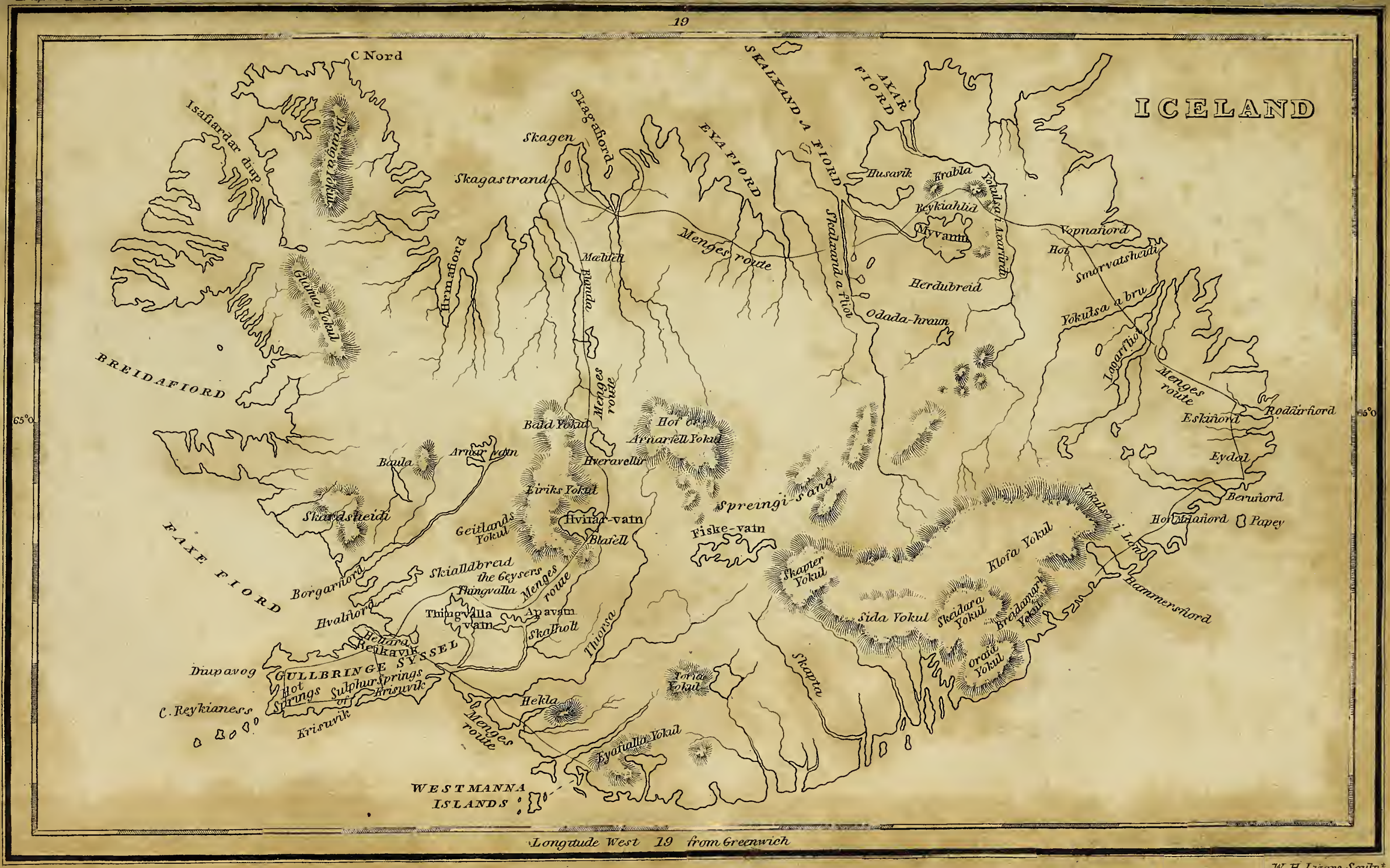

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PHILOSOPHICAL JOURNAL.

ART. I.—*History of the Origin of Mr Watt's Improvements on the Steam-Engine.* Contained in a letter from the late JAMES WATT, Esq. LL. D. F. R. S. Lond. and Edin. Member of the National Institute of France, and of the Batavian Society of Rotterdam, to David Brewster, LL. D. F. R. S. &c. *

DEAR SIR,

AT your request, I have carefully perused my late excellent friend Dr Robison's articles " Steam" and " Steam-Engines," in the Encyclopædia Britannica, and have made remarks upon them in such places where, either from the want of proper information, or from too great a reliance on the powers of his extraordinary memory, at a period when it probably had been weakened by a long state of acute pain, and by the remedies to which he was obliged to have recourse, he had been led into mistakes in regard to facts, and also in some places where his deductions have appeared to me to be erroneous.

There had been but very little interchange of letters between us for some years previous to his writing those articles, and our opportunities of meeting had been rare, and of short duration, and not occupied by philosophical discussions. Had I been apprised of his design, I might at least have prevented the errors respecting the facts in which I was concerned; but, upon the whole, it is more surprising to me that his recollection should have served him so well in narrating transactions of thirty years standing, than that it should sometimes have led him astray. If I had not retained some memorandums made at the time of, or soon after, their occurrence, I should myself have felt great difficulty in recalling to mind the particulars at the period when I first perused those articles, which was some time after their publication. I had about that period an opportunity of personally stating to Dr Robison some remarks upon them, of which he availed himself to a small extent in the Supplement to the Encyclopædia Britannica, and probably would have done so still more, had he been called upon to remould these articles.

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* This letter, which has not yet been published, was written under circumstances which will be stated in a subsequent memoir of the life of Mr Watt, and it cannot fail to be regarded as an interesting document in the history of his brilliant inventions. It was composed as an introduction to the account of the Steam Engine, which forms part of Dr Robison's System of Mechanical Philosophy, now in the press; and as it will be necessary to refer to it from our Account of Mr Watt's Life, we have gratified our readers with the entire letter, by the permission of his son, the present James Watt, Esq. of Heathfield, and of Dr Brewster, to whom it was addressed.—ED.

I have endeavoured to throw most of my corrections into the form of notes; but in some places I judged it necessary to alter the text; which alterations I have marked to be printed in Italics, that they may be readily distinguished from the original. In a few places I have cancelled part of the text without any substitution, none appearing to me to be required. In others I have left part of the reasoning unaltered which I did not concur in; as in mere matters of opinion, where no manifest error was involved, I did not conceive it proper to introduce my own speculations.

As the subjects of Steam, and Steam-Engines, had been almost dismissed from my mind for many years previous to my undertaking this revision, I have called in the aid of my friend Mr John Southern, and of my son, whose daily avocations in the manufacture of steam-engines, render them more conversant with some points, to direct my attention to them; and of the former, to examine such of the algebraic formulæ as appeared essential, an office for which he is much better qualified than myself; and he has accordingly marked those formulæ with his initials.

I have not attempted to render Dr Robison's memoir a complete history of the Steam-Engine; nor have I even given a *detailed* account of my own improvements upon it. The former would have been an undertaking beyond my present powers, and the latter must much have exceeded the limits of a commentary upon my friend's work. I have therefore confined myself to correcting such parts as appeared necessary, and to adding such matter as he had not an opportunity of knowing.

Here it was my intention to have closed this letter; but the representations of friends, whose opinions I highly value, induce me to avail myself of this opportunity of noticing an error into which not only Dr Robison, but apparently also Dr Black, has fallen, in relation to *the origin* of my improvements upon the Steam-Engine, and which not having been publicly controverted by me, has, I am informed, been adopted by almost every subsequent writer upon the subject of Latent Heat.

Dr Robison, in the article Steam-Engine, after passing an encomium upon me, dictated by the partiality of friendship, qualifies me as the "*pupil* and intimate friend of Dr Black;" a description which, not being there accompanied with any inference, did not particularly strike me at the time of its first perusal. He afterwards, in the dedication to me of his edition of Dr Black's Lectures upon Chemistry, goes the length of supposing me to have professed to owe my improvements upon the Steam-Engine to the instructions and information I had received from that gentleman, which certainly was a misapprehension, as, though I have always felt and acknowledged my obligations to him for the information I had received from his conversation, and particularly for the knowledge of the doctrine of Latent Heat, I never did, nor *could*, consider my improvements as originating in those communications. He is also mistaken in his assertion, p. 8. of the Preface to the above work, that "I had attended two courses of the Doctor's Lectures *;" for, unfortunately for me, the necessary avocations of my business prevented me from attending his or any other lectures at College; and as Dr Robison was himself absent from Scotland for four years at the period referred to, he must have been misled by erroneous information. In page 184 of the Lectures, Dr Black says, "I have the pleasure of thinking that the knowledge we have acquired concerning the nature of elastic vapours, in consequence of my fortunate observation of what happens in its formation and condensation, has contributed in no inconsiderable degree to the public good, by *suggesting* to my friend Mr

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* Repeated more in detail, with the same erroneous inferences, in his note, vol. i. p. 504.

Watt of Birmingham, then of Glasgow, his improvement on this useful engine," (meaning the steam-engine, of which he is then speaking). There can be no doubt, from what follows in his description of the engine, and from the very honourable mention which he has made of me in various parts of his Lectures, that he did not mean to lessen any merit that might attach to me as an inventor; but, on the contrary, he always was disposed to give me fully as much praise as I deserved. And were that otherwise doubtful, it would, I think, be evident from the following quotation from a letter of his to me, dated 13th February 1783, where, speaking of an intended publication by a friend of mine on subjects connected with the history of steam, he says, "I think it is very proper for you to give him a short account of your discoveries and speculations, and *particularly to assert clearly and fully your sole right to the honour of the improvements of the Steam-Engine*;" and in a written testimonial which he very kindly gave on the occasion of a trial at law against a piracy of my invention, in 1796–7, after giving a short account of the invention, he adds, "*Mr Watt was the sole inventor of the capital improvement and contrivance above mentioned.*" Under this conviction of his candour and friendship, it is very painful to me to controvert any assertion or opinion of my revered friend; yet in the present case I find it necessary to say, that he appears to me to have fallen into an error, and I hope, in addition to my assertion, to make that appear by the short history I have given of my invention in my notes upon Dr Robison's essay, as well as by the following account of the state of my knowledge previous to my receiving any explanation of the doctrine of Latent Heat, and also from that of the facts which principally guided me in the invention.

It was known very long before my time, that steam was condensed by coming into contact with cold bodies, and that it communicated heat to them. Witness the common still, &c. &c.

It was known by some experiments of Dr Cullen, and others, that water and other liquids boiled *in vacuo* at very low heats; water below 100°.

It was known to some philosophers, that the capacity or equilibrium of heat, as we then called it, was much smaller in mercury and tin than in water.

It was also known, that evaporation caused the cooling of the evaporating liquid, and bodies in contact with it.

I had myself made experiments to determine the following facts.

1*st*, The capacities for heat of iron, copper, and some sorts of wood, comparatively with water. Similar experiments had also subsequently been made by Dr Irvine, on these and other metals.

2*d*, The bulk of steam was compared with that of water.

3*d*, The quantity of water which could be evaporated in a certain boiler by a pound of coals.

4*th*, The elasticities of steam at various temperatures greater than that of boiling water, and an approximation to the law which it followed at other temperatures.

5*th*, How much water, in the form of steam, was required every stroke by a small Newcomen's engine, with a wooden cylinder six inches diameter, and twelve inches long in the stroke.

6*th*, I had measured the quantity of cold water required in every stroke to condense the steam in that cylinder, so as to give it a working power of about 7 lb. on the inch.

Here I was at a loss to understand how so much cold water could be heated so much by so small a quantity in the form of steam, and applied to Dr Black, and then first understood what was called Latent Heat.

But this theory, though useful in determining the quantity of injection necessary where the quantity of water evaporated by the boiler, and used by the cylinder, was known, and in determining, by the quantity and heat of the hot water emitted by Newcomen's engines, the quantity of steam required to work them, did not lead to the improvements I afterwards made in the engine. These improvements proceeded upon the old-established fact, that steam was condensed by the contact of cold bodies, and the later known one, that water boiled *in vacuo* at heats below 100°, and consequently that a vacuum could not be obtained unless the cylinder and its contents were cooled every stroke to below that heat.

These, and the degree of knowledge I possessed of the elasticities of steam at various heats, were the principal things it was *necessary* for me to consider in contriving the new engine. They pointed out that, to avoid useless condensation, the vessel in which the steam acted upon the piston ought always to be as hot as the steam itself; that to obtain a proper degree of exhaustion, the steam must be condensed in a separate vessel, which might be cooled to as low a degree as was necessary, without affecting the cylinder; and that as the air and condensed water could not be blown out by the steam as in Newcomen's, they must be extracted by a pump, or some other contrivance; that, in order to prevent the necessity of using water to keep the piston air-tight, and also to prevent the air from cooling the cylinder during the descent of the piston, it was necessary to employ steam to act upon the piston in place of the atmosphere. Lastly, to prevent the cylinder from being cooled by the external air, it was proper to inclose it in a case containing steam, and again to inclose that in a case of wood, or of some other substance which transmitted heat slowly.

Although Dr Black's theory of latent heat did not *suggest* my improvements on the steam-engine, yet the knowledge upon various subjects which he was pleased to communicate to me, and the correct modes of reasoning, and of making experiments, of which he set me the example, certainly conduced very much to facilitate the progress of my inventions; and I still remember with respect and gratitude the notice he was pleased to take of me when I very little merited it, and which continued throughout his life.

To Dr Robison I am also bound to acknowledge my obligations for very much information and occasional assistance in my pursuits, and above all, for his friendship, which ended only with his life; a friendship which induced him, when I was beset with an host of foes, to come to London in the depth of winter, and appear as a witness for me in a court of justice, whilst labouring under an excessively painful disorder, which ultimately deprived him of life. To the remembrance of that friendship is principally owing my taking upon myself the office of his commentator at my advanced age.

May I request, Sir, that you and the public will permit that age to be my excuse for any errors I may have committed, and for any deficiencies in the performance of an office which at no period would have been congenial to my habits; and allow me to remain with esteem, Dear Sir, your most obedient humble servant,

JAMES WATT.

HEATHFIELD, *May* 1814.

ART. II.—*Account of some remarkable Ripples, observed near the northern entrance of the Straits of Malacca.* Communicated by the Author *.

IN his Majesty's ship Minden, in 1814, a number of singular Ripples were observed between the north end of Sumatra and the Nicobar Islands; and also between that line and Pulo Penang, or Prince of Wales' Island. None of these islands, however, were in sight; and there were no soundings.

These ripples varied from two to five miles in length, and from two to four hundred yards in breadth: their direction was nearly north and south; they were always first descried in the west, or south-west; from that quarter they approached and passed the ship, and then went off to the east or north-east. In their general appearance they resembled the waves of the sea breaking on a shallow sandy shore. The waves forming the ripple, did not tumble against one another irregularly, but curled and broke in the direction towards which the whole ripple was advancing. When the sea breaks on a sandy beach, and forms what is called Surf, the waves stretch along parallel to the shore, and when they break, roll in upon it, one after the other; but in these ripples, the waves were not so continuous, and, when they broke, the water, instead of rolling along like surf, splashed up perpendicularly to a considerable height.

Some of the ripples were very gentle, so that the surface of the sea was scarcely whitened by them, their approach being indicated only by a faint noise. Others were heard several miles off, and advanced towards the ship, boiling and foaming in an extraordinary manner. Some of them not only dashed the water many feet up the side, but actually shook the ship in a very sensible degree.

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* Although this paper is anonymous, yet we are well acquainted with the able author of it, who, for reasons of his own, withholds his name from the public. We mention this, for the purpose of informing our Correspondents, that no communications are admissible unless we know the name of their author; and of requesting those who have sent us communications of this kind, to favour us with their names.—ED.

As we approached the line joining the north end of Sumatra and the Nicobar Islands, the ripples became more frequent and more violent. During the 5th of September, one passed the ship about every quarter of an hour. The wind at this time was between north-east and east, very light and variable, and sometimes calm; which rendered the effect of these ripples during the stillness of the night not a little striking. At first, a low hollow sound was heard, like that caused by a surf on a distant coast: it gradually became louder and louder; till at length a long foaming streak was discovered advancing rapidly towards the ship, which it soon surrounded, and then all was noise and commotion. This lasted for a few minutes, when the ripple moved past to the north-east, its sound becoming fainter and fainter; and it often occurred, that just as one ceased to be heard, another was perceived, and so on during all the night. Notwithstanding our distance from the shore, it was impossible to be without some alarm at first, when thus completely surrounded by breakers, habitually associated in the minds of sailors with the most formidable of all dangers.

During one evening the following curious phenomenon was observed. Whenever the ship entered one of the ripples, the wind immediately freshened, and at the same time changed its apparent direction; but, upon quitting the ripple, the wind invariably resumed its original velocity and direction.

Before suggesting any theory to account for this circumstance, it is right to state the facts precisely. The wind, which was very light, was blowing from north-east by north, (nearly N. 34° E.) The ship's head was west south-west, (W. 22½ S.), so that her course formed with the wind an angle of 146°. The rate of sailing was one mile and a half in the hour. When the ship entered the ripple, the wind invariably changed to north; or, to speak more correctly, the vane, which before stood north-east by north, was now turned to north, so as to form an angle of only 112° with the course. At the same moment, an obvious increase in the strength of the wind took place. On getting into smooth water again, the vane returned to north-east by north, and the wind instantly lulled.

This phenomenon may be accounted for in two ways; either by supposing that there actually was a change in the force and direction of the wind incident to the ripples alone, or else that there was a local current which belonged to them, and not to the contiguous sea. It seems less difficult to conceive the last supposition; which we are farther led to adopt, from having discovered, by means of chronometers, and good meridian altitudes of the sun and stars, that the ship, during the day, had actually been set to the north-west by west, (N. 56 W.) at the rate of nearly one mile an hour, strictly 0.79 of a mile *. A reference to the figure, Plate I. Fig. 1., will shew how a current in that direction would account for the facts. Let the shaded space FG be the ripple, AB the ship's course (west south-west,) before entering it, and H the direction of the wind. On entering the ripple at B, suppose the influence of the current to commence, then the ship's true course, or the path she actually takes, will be the diagonal of the parallelogram of which the ship's apparent course and rate of sailing furnish one side, say W. S. W. 1.88 (BC), and the temporary current N. W. b. W. 6.84 (CD) another; then the true course, while in the ripple, will be W. N. W. 8, (BD) †; DE, the course after quitting it, as before, W. S. W. Now, it is clear, that if a ship sailing in the direction AB with the wind H, is suddenly carried out of her course in the direction BD, an apparent alteration in the wind must take place. The degree of this change will depend upon the relative velocities of the wind and the current. If the velocity of the wind in both cases could be exactly determined, together with the change in the angle of its direction, a means of ascertaining the force and direction of the current would be afforded. The experiment, indeed, would require much care and nicety; but as the result might lead to the most important conclusions in the very obscure subject of currents, it is greatly to be desired that navigators would permit no opportunity to pass, without endeavouring to furnish more accurate observations.

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* The accurate Captain Horsburgh, in describing these ripples, says, that they are not always accompanied by currents.

† These numbers, 1.88, &c. serve merely to express the supposed *ratio* of the velocities of the two forces acting on the ship, and that of the resultant or true course.

It is worthy of remark, that while the ripples proceeded past the ship in a north-easterly direction, the ship was ascertained to have been set by a current to the north-westward. In the above account it is suggested, that the current was incident to the ripples alone; but future observers, furnished with good chronometers, would do well to ascertain whether this be the case or not. The rate at which the ripples themselves proceed, and their direction, ought also to be carefully observed.

Dr Wollaston, upon seeing the above statement, suggested, that the ripples might possibly be caused by the meeting of great waves coming from different oceans. In the case described, such waves may be supposed to have come from the Bay of Bengal, or the northern parts of the Indian Ocean on the one hand, and from the southern Indian Ocean on the other. This hypothesis is at least extremely ingenious, and worthy of the attentive consideration of navigators, who may have opportunities of re-examining these interesting phenomena.

VEGA.

ART. III.—*On the Colour of the Greenland Sea.*—By W. SCORESBY *jun.*, F. R. S. E., and M. W. S [*].

THE colour of the Greenland Sea varies from ultramarine blue to olive green, and from the most pure transparency to great opacity. These appearances are not transitory, but permanent; not depending on the state of the weather, but on the quality of the water. Hudson, when he visited this quarter in the year 1607, noticed the changes in the colour of the sea, and made the observation, that the sea was blue where there was ice, and green where it was most open. This circumstance, however, was merely accidental. Captain Phipps does not appear to have met with any of the green water. This kind of water occurs in considerable quantity, forming, perhaps, one-fourth part of the surface of the Greenland Sea, between the parallels of 74° and 80°. It is liable to alterations in its position, from the action of the current; but still it is always renewed, near certain situations, from year to year. Often it constitutes long bands or streams, lying north and south, or north-east and south-west; but of very variable dimensions: sometimes, I have seen it extend two or three degrees of latitude in length, and from a few miles, to ten or fifteen leagues in breadth. It occurs very commonly about the meridian of London, in high latitudes. In the year 1817, the sea was found to be of a blue colour, and transparent, all the way from 12° east, in the parallel of 74° or 75°, to the longitude of 0° 12′ east, in the same parallel. It then became green, and less transparent. The colour was nearly *grass-green*, with a shade of black. Sometimes the transition between the green and blue water is progressive, passing through the intermediate shades in the space of three or four leagues; at others, it is so sudden, that the line of separation is seen like the rippling of a current; and the two qualities of the water keep apparently as distinct as the waters of a large muddy river, on first entering the sea. In 1817, I fell in with such narrow stripes of various coloured water, that we passed streams of pale green, olive green, and transparent blue, in the course of ten minutes sailing.

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[*] Extracted, by permission of the author, from his *Account of the Arctic Regions*, now in the press.—ED.

The food of the whale occurs chiefly in the green coloured water; it therefore affords whales in greater numbers than any other quality of the sea, and is constantly sought after by the fishers. Besides, whales are more easily taken in it, than in blue water, on account of its great obscurity preventing the whales from seeing distinctly the approach of their enemies.

Nothing particular being observed in this kind of water, sufficient to give it the remarkable colour it assumes, I at first imagined that this appearance was derived from the nature of the bottom of the sea. But on observing that the water was very imperfectly transparent, insomuch that *tongues* of ice, two or three fathoms under water, could scarcely be discerned, and were sometimes invisible, and that the ice floating in the olive-green sea was often marked about the edges with an orange-yellow stain, I was convinced that it must be occasioned by some yellow substance held in suspension by the water, capable of discolouring the ice, and of so combining with the natural blue of the sea, as to produce the peculiar tinge observed.

For the purpose of ascertaining the nature of the colouring substance, and submitting it to a future analysis, I procured a quantity of snow from a piece of ice that had been washed by the sea, and was greatly discoloured by the deposition of some peculiar substance upon it. A little of this snow, dissolved in a wine glass, appeared perfectly nebulous; the water being found to contain a great number of semi-transparent spherical substances, with others resembling small portions of fine hair. On examining these substances with a compound microscope, I was enabled to make the following observations.

The semi-transparent globules appeared to consist of an animal of the medusa kind. It was from 1–20th to 1–30th of an inch in diameter. Its surface was marked with twelve distinct patches or nebulæ, of dots of a brownish colour; these dots were disposed in pairs, four pairs, or sixteen pairs alternately, composing one nebula. The body of the medusa was transparent. When the water containing these animals was heated, it emitted a very strong odour, in some respects resembling the smell of oysters, when thrown on hot coals, but much more offensive. The fibrous or hair-like substances, were more easily examined, being of a darker colour. They varied in length from a point to one-tenth of an inch; and when highly magnified, were found to be beautifully moniliform. In the longest specimens, the number of bead-like articulations was about thirty; hence their diameter appeared to be about the 1–300th part of an inch. Some of these substances seemed to vary their appearance; but whether they were living animals, and possessed of locomotion, I could not ascertain. From one of the larger specimens I observed some fine collateral fibres. They possessed the property of decomposing light; and, in some cases, showed all the colours of the spectrum very distinctly. The size of the articulations seemed equal in all, the difference in length being occasioned by a difference in the number of articulations. The whole substance had an appearance very similar to the horns or antennæ of shrimps, fragments of which they might possibly be, as the squillæ are very abundant in the Greenland Sea.

I afterwards examined the different qualities of sea-water, and found these substances very abundant in that of an olive-green colour; and also occurring, but in less quantity, in the bluish-green water. The number of medusæ in the olive-green sea was found to be immense. They were about one-fourth of an inch asunder. In this proportion, a cubic inch of water must contain 64; a cubic foot 110,592; a cubic fathom

23,887,872; and a cubical mile about 23,888,000,000,000,000! From soundings made in the situation where these animals were found, it is probable the sea is upwards of a mile in depth; but whether these substances occupy the whole depth is uncertain. Provided, however, the depth to which they extend be but 250 fathoms, the above immense number of one species may occur in a space of two miles square. It may give a better conception of the amount of medusæ in this extent, if we calculate the length of time that would be requisite, with a certain number of persons, for counting this number. Allowing that one person could count a million in seven days, which is barely possible, it would have required, that 80,000 persons should have started at the creation of the world, to complete the enumeration at the present time!

What a stupendous idea this fact gives of the immensity of creation, and of the bounty of Divine Providence, in furnishing such a profusion of life in a region so remote from the habitations of men! But if the number of animals in a space of two miles square be so great, what must be the amount requisite for the discoloration of the sea, through an extent of perhaps twenty or thirty thousand square miles!

These animals are not without their evident economy, as on their existence possibly depends the being of the whole race of mysticete, and some other species of cetaceous animals. For, the minute medusæ apparently afford nourishment to the sepiæ, actiniæ, cancri, helices, and other genera of Mollusca and Aptera, so abundant in the Greenland Sea, while these latter constitute the food of several of the whale tribe inhabiting the same region; thus producing a dependent chain of animal life, one particular link of which being destroyed, the whole must necessarily perish.

Besides the minute medusæ and moniliform substances, the water of the Spitzbergen Sea, taken up in latitude 77° 30′, was found to contain several species of animalcules. Of these I discovered three kinds, full of animal life, but invisible to the naked eye.

There can be no doubt, I think, after what has been advanced, that the medusæ and other minute animals that have been described, give the peculiar colour to the sea, which is observed to prevail in these parts; and that from their profusion, they are, at the same time, the occasion of that great diminution of transparency which always accompanies the olive-green colour. For in the blue water, where few of the little medusæ exist, the sea is uncommonly transparent. Captain Wood, when attempting the discovery of a north-east passage, in the year 1676, sounded near Nova Zembla in 80 fathoms water, where the bottom was not only to be seen, but even the shells lying on the ground were clearly visible.

Never having been in a very high latitude during any part of the year when the sun sets, I have never observed whether the Greenland Sea possesses the property of shining in the dark. There is, however, great reason to believe, that as the luminousness of the sea is often derived from small animals of the medusa kind, that the green-coloured water found in the Greenland Sea would be strongly phosphorescent.

Art. IV.—*On Poppy Oil.* By John Young, Fellow of the Royal College of Surgeons of Edinburgh.

The cultivation of the poppy to a great extent, for the benefit of its oil, as an article of food, and for other useful purposes, has long been carried on in France, Brabant and Germany, and more recently in Holland.

Although it was long since known that the seed of the poppy, and the oil obtained from it, do not possess narcotic properties, and that it was baked into cakes, and used as an article of food by the ancients, yet there has been much contention respecting the propriety of using it. In France, about the beginning of the seventeenth century, the opposition to the general use of poppy oil, as an article of food, became so violent, that the Lieutenant-General of the Police of Paris ordered the medical faculty of that city to make the strictest examination concerning this point; and they reported, that as there is nothing narcotic or prejudicial to health in the oil, the use of it might be permitted. But this decision was unsatisfactory; and popular clamours determined the court to pass a decree in the year 1718, prohibiting the sale of poppy oil, whether mixed or unmixed.

The sale of the article, however, was clandestinely encouraged, and gradually increased, until the year 1735, when the court issued a severer decree, enjoining the superintendants to mix a certain quantity of the extract of turpentine with every cask containing 1100 lb. of this oil, of which not less than 2000 casks were consumed in Paris alone.

But the secret demand for it increased till the year 1773, when a society of agriculture undertook to examine all that had been alleged for and against the general use of this oil. Experiments were repeated in the presence of the most distinguished chemists, and the society presented a petition to the Minister of Police, setting forth the great advantages that would accrue, both to commerce and agriculture, by reversing the prohibition. This society again made several experiments in the year 1776, and finally confirmed the decree of the faculty in 1717, declaring that the oil of poppies was not injurious to the health; that it did not contain a narcotic power, and that it might be recommended to general use with the utmost safety. From that time to the present, the cultivation of the poppy has not met with any formidable opposition, and has increased to such a degree, both in France and Brabant, that they have been able to export a considerable surplus, to the great advantage of the husbandman as well as the merchant; and in seasons of scarcity it has been found of the most essential service in all cases where the use of oil was required. In the northern parts of France, it was used by soap-boilers as a substitute for other oils, which were extremely dear; and in Brabant the oil-cakes are constantly used as food for cattle, with obvious benefit.

It is well known that maw-seed, obtained from a variety of the poppy, has long been used in this country for feeding birds. I have a canary that has been fed upon white poppy-seed for many months; and I supplied a person with this seed who breeds canary birds for sale. He gives them nothing else to eat, and observes that they thrive as well as when fed upon common seed. According to Dr Alston *, the poppy seed is used in food in some places, as well as the expressed oil, which, he says, is as innocent and wholesome as olive oil. And Mr Kerr † relates,

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* *Edin. Med. Essays*, vol. v. p. 110. † *Lond. Med. Observ.* vol. v. p. 319.

that the seeds of the poppy are sold in the markets, and are reckoned delicious eating; they are used in emulsions, and enter into the cooling prescriptions of the Hindostan physicians. This is corroborated by A. W. Davis *: According to him, the seeds are valuable for the oil they contain; and, as an article of food, are in great request with the natives; and when used in this way, it is scarcely to be distinguished from olive oil, which is often adulterated with it †. I have seen large quantities of poppy seed exposed for sale in the bazaar of Calcutta.

We are told by Mr C. A. Fisher, in his Letters written during a journey to Montpellier, in the year 1804, that the oil of Provence, which, on account of its purity, mildness, and fine flavour, is famous all over Europe, is exported to Italy in large quantities, and was formerly exported to many distant countries; but since the hard winters of 1789 and the following years, so many olive trees have been frozen, and, during the revolution, so few planted, that Aix (which was the principal seat of its traffic) has now entirely lost its first and most lucrative branch of commerce.

Two inferences may be drawn from the preceding observation. Our best oils, though imported from Italy, are probably of the growth of Provence, and it is still more probable that the inferior sorts could not be afforded, even at the present price, without a large *mixture of the poppy oil.*

It is generally admitted, that certain crops sown according to the drill system, come to greater perfection than when sown in the broad-cast way. That this is the case with the poppy, will appear from the following statement.

In cultivating the poppy for opium, I sowed it in three different ways.

The first broad-cast, upon beds three feet wide, with an alley between, and thinned out to the distance of four and five inches.

The second on beds three feet wide, in rows, six rows to a bed, and six inches between the plants.

The third on the spaces between rows of early potatoes, four feet wide. Two rows of poppies on each space; twelve inches between the rows of poppies, and eight inches between the poppy plants: Three feet between each double row of poppies occupied by one row of early potatoes.

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* *Transactions of the Society of Arts*, vol. xvi. p. 275.

† Rees's *Cyclopædia*, vol. xxv. art. Oil of Poppy Seed or Pink Oil.

The first produced only one capsule, the second two, and the third produced, upon an average, four full-grown capsules; some of the last had seven or eight capsules.

The seed of the poppy comes to maturity after the extraction of the opium. And when it is considered that it yields more than a third part of its weight of oil, and that a crop of early potatoes, equal to 36 bolls per acre, can be raised by the same culture upon the same space of ground, with a crop of opium equal to 56 lb., there is scarcely any plan that can be devised which would prove equally profitable to the cultivator, or more beneficial to the community.

One acre of poppies cultivated in wide drills, as I have already described, will produce, in a good season, 1000 lb. of seed, which will give by expression 375 lb. of oil.

After the opium harvest is over, the seeds will be ready for gathering about the end of August. This is to be done by drawing the entire plants out of the ground, binding a sufficient number together, and placing them against each other, in the manner of corn-sheaves, and letting the whole remain in the field a few days, until they are perfectly dry; then laying the sheaves upon a large cloth, bruise the capsules and shake out the seed, which is afterwards to be passed through a sieve of a proper size.

It is advisable to extract the oil as soon after the harvest as possible, as the seeds will yield a larger quantity than when long kept; besides, when the seed is long kept, the oil will neither be so good nor so well coloured. It is of the utmost importance that mill, press and bags, be perfectly clean and pure.

The first oil is destined for the use of families; this is cold drawn, as any degree of warmth injures the flavour. After as much is extracted in this manner as possible, a considerable quantity, of inferior quality, is obtained, by heating the cakes, and pressing them a second time.

That which is at first expressed is of a pale colour; is peculiarly bland and soft; has a flavour approaching that of the almond oil; it is used for salads and other domestic purposes, either alone or mixed with olive oil. Should the latter be stale or rancid, it will be considerably improved by a mixture of recent poppy oil.

The oil expressed must remain for five or six weeks before it is used, that it may deposit in a sediment a kind of milky substance that is mixed with it. It must then be poured into another vessel, and this should not be perfectly closed at first, but the opening be covered with a linen cloth or a pricked bladder, that certain exhalations may pass; nor should the oil be immediately used after the process is finished, as it continues to improve for a considerable length of time.

Holland was supplied with this oil for a considerable time from France. It was sold there under the name of olive oil, or mixed with it in considerable abundance; and it is believed that a great proportion of the olive oil used in this country is mixed with poppy oil.

The second drawn oils are of a deeper colour, and are applicable to all the purposes of the more common oils; and artists give a preference to the finer sort of it as a drying oil. It preserves the colour of some kinds of paint better than the other drying oils, and is free from their disagreeable smell.

Dr Cogan * states, that in the year 1799 the poppy was cultivated in Holland solely for its oil and oil cakes, which yielded a profit of about L. 8 Sterling per acre, after paying expences. The oil of the first quality at that time being valued at 5s. 6d. and the second at 5s. per gallon. But when it is considered that the poppy is proposed to be cultivated in this country for a more valuable purpose than for its oil only, the additional expence of collecting the seeds, and expressing the oil, will bear but a small proportion to that incurred in Holland. For it appears that there the expence amounts to more than half the value of the whole crop.

Estimated value of the produce of one acre,

250 lb. oil, cold drawn, at 1s. 6d. - -	L. 18	15	0
125 lb. do. warm. at 6d. - - -	3	2	6
500 oil cakes, at 18s. per 100, - - - -	4	10	0
	L. 26	7	6

The following account will give an idea of the proportion of oil which the seed contains, and the expence of pressing, &c.

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* *Bath Papers*, vol. x. art. 28.

London, 2d January 1819.

Mr J. Young,

To Thos. Davy, Son & Mends.

For expences on 86 lb. Sem. Pap. alb. received from him for pressing, producing

32¼ lb of oil, Sem. pap. alb.
43 lb. cake.

Viz. Bottle for oil, 3s. 8d. Proportion of expences up, 4s.	L. 0	7	8
Pressing 86 lb. at 19s.	0	14	7
Hamper, 2s. 6d. Shipping, 1s.	0	3	6
	L. 1	5	9

From this account there appears to have been a loss of 11 lb. of the weight. But it is evident the proportion of loss would be much less when conducted upon a large scale; and had the seed been more recently collected, the proportion of oil would have been much greater.

Should the oil of superior quality answer the description given of it, and be more palatable than the olive oil in common use, 12s. per gallon may perhaps be too low an estimate. Salad oil is at present sold at 2s. 6d. or 3s. per English pint.

Art. V.—*Account of a new Style of Engraving on Copper in Alto Relievo, invented by* W. Lizars. Drawn up from information communicated by the Inventor.

THE progress which has been made during the last thirty years, in the Mechanical Arts, and in the application of Science to the useful purposes of life, has been no less remarkable for its rapidity, than for the variety and importance of the inventions by which it has been marked. The history of the Fine Arts during the same period, though it does not present us with any very splendid achievements, has yet to record some striking specimens of their advancement. One of the most important of these, is undoubtedly the invention of Lithography; an art by which copies of drawings of all kinds can be multiplied with such a degree of accuracy and facility, as to be a complete substitute for copper-plate engraving, and, at the same time, at such a cheap rate, that the original cast of the stone, and the expence of preparing it, either by a transference of the drawing to be multiplied, or by a direct delineation of it upon the stone, bears almost no proportion to the expence of cutting it on copper.

It is impossible to speak too highly of the great advantages of stone-printing, in those cases to which it is really applicable; but there is some risk of forming too high an estimate of it's powers, and we fear that the public expectations are too sanguine to be ultimately gratified.

In all these cases, where the expence of copper-plate engraving is very great, compared with the expence of paper, and of taking off the impression, whether this difference arises from the smallness of the number of impressions, or from the difficulty of the engraving, the art of lithography is peculiarly valuable. But when the subject to be engraved is a mere outline, such as diagrams, the expence of cutting which on copper is very trifling, or when the expence of paper and of taking the impression is very great, from the number of impressions to be thrown off, then the original cost of the engraving, even if it has much work upon it, forms such a small part of the whole expence, that it would not be advisable to multiply it by stone printing.

When we consider that the expence of paper is the same in both arts; and that the method of taking impressions from stone, is more troublesome and less certain than in taking them from copper, we shall have no difficulty in distinguishing the particular cases in which we should have recourse to lithography.

The art of engraving upon wood, though imperfect from the very nature of the process, possesses great advantages. If we wish to illustrate a subject by a single diagram, we are enabled to do it by a wood engraving, which is printed from it along with the types, and which therefore saves all the expence of throwing off the impressions separately, and also the expence of a separate leaf of paper. In many instances this saving amounts to a great sum, and the original expence of the wood engraving is comparatively nothing. We have, besides, the great advantage of having the diagram or figure adjacent to the description of it, an advantage which those only can appreciate who spend much of their time in the study of mathematical and physical works.

The new art of engraving upon copper, which Mr Lizars has invented, is a substitute for wood engraving, in the same manner as lithography is a substitute for copper-plate engraving; but while Mr Lizars has given us a cheaper art for a more expensive one, he has also given us a more perfect art for one which is full of imperfections. The invention of lithography, on the contrary, was the substitution of an imperfect for a perfect art, and whatever progress it may yet make, we can never expect it to exhibit that union of bold and delicate touches by which stroke engraving is characterised.

In wood engraving, as will be seen from the vignette on the cover of our Number, all the white parts are cut below the general surface of the wood, while all the black lines which constitute the picture, are left on the level of the general surface. Hence, it is impracticable to hatch or to leave upon the surface of wood elevated lines, which cross each other, without cutting out the small white lozenges, which would be a work of enormous labour, and by no means perfect, even if it could be accomplished. All the shadings, therefore, in wood engravings, are formed by parallel lines, which never cross one another, as will be seen in the vignette already mentioned. In copper-plate engraving, on the contrary, all the black lines are cut below the general surface, while the white parts correspond with the general surface of the copper. The art of hatching is therefore extremely easy in this art, and we have only to cross the lines cut out by the engraver in the same manner as we do them in drawing with the pen.

These observations will prepare the reader for understanding Mr Lizars' invention, and for forming a correct estimate of its value.

The following account of it has been kindly communicated to us by himself.

In the operation of engraving, the desired effect is produced by making incisions upon the copper-plate with a steel instrument of an angular shape, which incisions are filled with printing-ink, and transferred to the paper by the pressure of a roller, which is passed over its surface. There is another mode of producing these lines or incisions by means of diluted nitrous acid, which is well known, and in which the impression is taken in the same way. The new mode of engraving is done upon a principle exactly the reverse, for instead of the subject being cut into the copper, it is the interstice between these lines which is removed by diluted acid, (commonly called Aquafortis,) and the lines are left as the surface: from which the impression is taken, by means of a common type printing-*press*, instead of a copper-plate press.

This is effected by drawing with turpentine varnish, coloured with lamp-black, whatever is required upon the plate, and when the varnish is thoroughly dry, the acid is poured upon it, and the interstice of course removed by its action upon the uncovered part of the copper. If the subject is very full of dark shading, this operation will be performed with little risk of accident, and with the removal of very little of the interstice between the lines; but if the distance between the lines is great, the risk and difficulty is very much increased, and it will be requisite to cut away the parts which surround the lines with a graver, in order to prevent the dabber with the printing-ink from reaching the bottom, and thus producing a blurred impression. It is obvious, therefore, that the more the plate is covered with work, the less risk will there be in the preparation of it with the acid, after the subject is drawn; and the less trouble will there be in removing the interstice (if any) from those places where there is little shading.

A great degree of facility will be obtained by etching out the first line with the common etching-needle, and afterwards putting on the cross line with the varnish; and by this means there will be much more variety, regularity, and beauty in the effect, than if the whole had been done with the varnish.

I have found from experience, that the best mode of proceeding is to lay an etching-ground upon the copper, as in the ordinary operation of etching; to remove the first lines, or rather *interstices*, with the needle, and then to put on the cross-lines with the varnish. Should this cramp the freedom of the artist in some parts, he can easily scrape off the etching-ground, and draw those with the varnish.

Although this discovery must still be considered in its infancy, and very incomplete, yet it is probable that much may be done with it, if proper materials can be found out to work with. It possesses every advantage which common engraving does, and at the same time all the advantages of engraving on wood; and, above all, it enables us to procure as many impressions as can be taken from types *. The greatest difficulty to be surmounted, is to obtain a substitute for the varnish, which will flow from a pen or pencil like Indian ink; for as the varnish has a tendency to dry, and get tough in the pencil, the operation is by this circumstance very considerably impeded. Other substances than copper may be used; and experience may prove them to be better adapted to the purpose. I have tried wood covered with white lead and strong glue, with considerable success, but not with so much as copper; and it may be as well, for the sake of those who may think it worth their while to make other trials, to mention, that I have used lead, pewter, type-metal, zinc, and brass, all with various success, but have still found copper superior to them all. Mr Sivright of Meggetland, a gentleman well known in this city for his scientific acquirements, and to whom, during these experiments, I was much indebted, used with very great success the same kind of limestone which is employed in lithography.

I have also tried various kinds of varnishes, viz. mastic varnish, japan, liquid etching-ground, copal varnish, and spirit varnish, but have found the best to be common turpentine varnish, or resin dissolved in turpentine.

EDINBURGH, *October* 1819.

ART. VI.—*On the Application of a new mode of Analysis to the theory and summation of certain extensive classes of Series.* By J. F. W. HERSCHEL, Esq. F. R. S., &c. Communicated by the Author.

THE first idea of separating the symbols used in analysis, to denote the operations by which one function is derived from another, from those employed to represent quantities themselves, and of expressing the relations subsisting between operations of different kinds, by equations among their characteristic letters, is due to M. Arbogast; and however wide and interesting the field it lays open to speculation, I am not aware that it has been much cultivated by others. In a late publication *, I have endeavoured to shew the elementary simplicity and luminous elegance which the use of this method is calculated to introduce in the method of differences; and in a paper printed in the Transactions of the Royal Society for 1816, have endeavoured to extend the method itself to cases not within the contemplation of its inventor, and to make it the basis of what I think may fairly be termed a new mode of symbolic representation, and one possessing peculiar advantages where it can be employed. In the following short essay, I might perhaps take for granted the fundamental theorem there demonstrated; but as the original proof is unnecessarily complicated, the following one, which is much shorter and more simple, will not be irrelevant.

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* I have not been able to find out the number of impressions which types will take, but I have been informed that an edition of 20,000 was printed from a Gaelic Testament at the University Press here, and stereotype plates *afterwards* cast from the same types without any apparent diminution of their sharpness.

(1.) Let $f(e^t)$ represent any function of e^t, (where $e=2.71828\ldots$) and let us suppose it developed in powers of t in the series,

$$A_0 + A_1 . t + A_2 . t^2 + \&c.$$

To determine the coefficient of t^x, we have

$$f(e^t) = f\left\{1 + (e^t - 1)\right\}$$

$$= f(1) + \frac{e^t - 1}{1} . f'(1) + \frac{(e^t - 1)^2}{1.2} . f''(1) + \&c.$$

Now, the co-efficient of t^x in $f(1)$ is $0^x \times f(1)$. in the second term $\frac{e^t f - 1}{1} . f'(1)$ it is $\frac{1^x - 0^x}{1} \times \frac{f'(1)}{1.2\ldots x}$. In the third, $\frac{(e^t - 1)^2}{1.2} . f''(1)$ or $\frac{e^{2t} - 2 . e^t + 1}{1.2} f''(1)$ it is $\frac{2^x - 2.1^x + 0^x}{1.2} \times \frac{f''(1)}{1.2\ldots x}$ and so on. But the numerators of these fractions are respectively the first, second, &c., differences of the xth powers of the natural numbers 0, 1, 2, &c., and denoting these by $\Delta 0^x$, $\Delta^2 0^x$, &c., the whole co-efficient of t^x will be

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* Translation of Lacroix's Differential and Integral Calculus.—Appendix.

$$\left\{f(1).\,0^x + f'(1).\,\frac{\Delta 0^x}{1} + f''(1).\,\frac{\Delta^2 0^x}{1.2} + \&c.\right\} \times \frac{1}{1.2.\ldots.x}$$

Now, if we observe that the symbol operated on (0^x) is the same in every term, and that any expression, such as $f(1+\Delta)\,0^x$ is only an abbreviated mode of denoting that, when developed in powers of Δ, each power so produced is to be applied immediately before the power of 0 annexed, with its proper co-efficient, we shall have for the abbreviated expression of the above co-efficient, $A_x =$

$$\frac{1}{1.2\ldots.x}\left\{f(1) + f'(1).\frac{\Delta}{1} + f''(1).\frac{\Delta^2}{1.2} + \&c.\right\}0^x$$

$$= \frac{f(1+\Delta)\,0^x}{1.2\ldots.x} \qquad \text{(A)}$$

(2.)—Thus, provided we have the means of estimating the value of $f(1+\Delta)\,0^x$, we are furnished with that of A_x; and *vice versâ*, if by any method the value of A_x become known, the value of $f(1+\Delta)\,0^x$ is given by the equation,

$$f(1+\Delta)\,0^x = 1.2\ldots.x\,A_x \qquad \text{(B)}$$

Now, here it must be remarked, that whatever be the form of f, whether algebraic or transcendental, the value of this expression is necessarily limited to a finite number of terms, by reason of the property of these differences, which gives $\Delta^m 0^x = 0$ for every value of m greater than x; so that the series of which $f(1+\Delta)\,0^x$ is an abbreviation, necessarily breaks off after $x+1$, terms though apparently continued to infinity.

(3.) The following values of $f(1+\Delta)\,0^x$ for different forms of the function f, will be useful to us hereafter.

$$(1+\Delta)^m\,0^x = m^x, \text{ whatever be the value of } m \qquad \text{(C)}$$

$$\frac{1}{1+\Delta}0^{2x} = 1; \qquad \text{(D)}$$

$$\frac{1}{2+\Delta}0^{2x-1} = (-1)^x.\,\frac{2^{2x}-1}{2x}\,B_{2x-1}; \qquad \text{(E)}$$

where B_{2x-1} is the x^{th} number of Bernouilli;

$$f\left\{(1+\Delta)^n\right\}0^x = n^x \times f(1+\Delta)\,0^x. \qquad \text{(F)}$$

which are immediate consequences of the equation B, if the particular form of f be substituted for the general.

(4.) Let us now consider the series

$$S = A_0 . 0^n + A_1 . 1^n + A_2 . 2^n + \&c.$$

By substituting here for 0^n, 1^n, 2^n, &c. their values derived from the equation

$$(1 + \Delta)^m . 0^x = m^x$$

we find

$$S = A_0 . (1 + \Delta)^0 0^n + A_1 . (1 + \Delta) 0^n + A_2 (1 + \Delta)^2 0^n + \&c.$$

or, separating the symbols of operation from those of quantity,

$$S = \left\{ A_0 (1 + \Delta)^0 + A_1 (1 + \Delta) + A_2 (1 + \Delta)^2 + \&c. \right\} 0^n$$

$$= F (1 + \Delta) 0^n .$$

if we suppose that the co-officients A_0, A_1, &c. are such that

$$F (t) = A_0 + A_1 t + A_2 t^2 + \&c.$$

We will exemplify this in a few particular instances.

(5.) Suppose we begin with the series

$$S = 1^n - 2^n + 3^n - \&c. \textit{ ad. inf.}$$

Here we have

$$F (t) = t - t^2 + \&c. = \frac{t}{1 + t}$$

and therefore

$$S = \frac{1 + \Delta}{2 + \Delta} 0^n .$$

This, then, is the abbreviated expression for the sum of the proposed series, but if we would obtain its numerical value, we must reduce this to a limited number of calculable terms, by developing $\frac{1 + \Delta}{2 + \Delta}$ in powers of Δ, and rejecting all beyond the nth, thus we get

$$S = \frac{0^n}{2} + \frac{\Delta 0^n}{4} - \frac{\Delta^2 0^n}{8} \cdots \frac{+ \Delta^n 0^n}{2^{n+1}} ;$$

and if we assign to n particular numerical values, we obtain precisely the same results with those long ago found by Euler.

If we take the series

$$1^n . t + 2^n . t^2 + 3^n . t^3 + \&c.$$

which is one of very frequent occurrence in analysis, our formula gives for its sum to x terms

$$\frac{t (1 + \Delta) - t^{x+1} (1 + \Delta)^{x+1}}{1 - t (1 + \Delta)} 0^n ;$$

and to infinity simply,

$$\frac{t\,(1+\Delta)}{1-t\,(1+\Delta)}\,0^n\,;$$

which reduced to a form adapted to numerical computation, becomes

$$\frac{0^n}{1-t}+\frac{t.\,\Delta\,0^n}{(1-t)^2}+\ldots\ldots\frac{t^n.\,\Delta^n\,0^n}{(1-t)^{n+1}}.$$

(6.) Not, however, to multiply instances, we shall now go on to the more extensive series, whose general term is

$$A_x\,(a+h\,x)^n.\ (a'+h'\,x)^{n'}.\ (a''+h''\,x)^{n''}\ldots\ldots$$

of which the series,

$$1^m.\,2^n.\,t+2^m\,3^n.\,t^2+3^m.\,4^n.\,t^3+\&c.$$

is a particular instance: but not to encumber ourselves with unnecessary symbols, the method being the same for any number, we will confine our analysis to two factors in each term.

If we denote by S the sum of the series, and observe that

$$(a+h\,x)^n=(1+\Delta)^{a+h\,x}\,0^n$$
$$(a'+h'\,x)^{n'}=(1+\Delta)^{a'+h'x}\,0^{n'}.$$

we have

$$S=A_0\,(1+\Delta)^a 0^n\times(1+\Delta)^{a'}0^{n'}+A_1\,(1+\Delta)^{a+h}\,0^n$$
$$\times\,(1+\Delta)^{a'+h'}\,0^{n'}+\&c.$$

In order to separate the symbols of operation from those of quantity in this case without confusion, we must resort to the system of accentuation I have explained in the paper in Philosophical Transactions 1816, above alluded to; thus, applying an accent to the latter Δ, and a corresponding accent to the 0 with which it is to be connected, we mark them as it were for each other, and a temporary separation by way of abbreviation or transformation will not be any source of confusion. We have then

$$S=\left\{A_0\,(1+\Delta)^a\,(1+\Delta')^{a'}+A_1\,(1+\Delta)^{a+h}\right.$$
$$\left.(1+\Delta')^{a'+h'}+\&c.\right\}0^n\,0'^{n'}$$

$$=(1+\Delta)^a\,(1+\Delta')^{a'}.\ F\left\{(1+\Delta)^h.\ (1+\Delta')^{h'}\right\}0^n\,0'^{n'}.$$

(7.) For example, the series $1^m. 2^n. t + 2^m. 3^n. t^2 +$ &c. has for its sum to infinity

$$\frac{(1+\Delta)(1+\Delta')^2. t}{1-t(1+\Delta)(1+\Delta)'} 0^m 0'^n ;$$

which is reduced to calculable terms by developement in powers of Δ and Δ', rejecting all those of the former beyond m, and of the latter beyond n. Its value to x terms may in like manner be readily expressed.

Thus in the case of the series 1.2 — 2.3 + 3.4 — &c. we find $\frac{1}{4}$ for the value of the above expression, the terms multiplied by $\Delta.\Delta'$ being the only ones to be retained in the developement; and this is the same result with that afforded by the usual process, though it is obvious that, to arrive by that process, or any general expression, (for arbitrary values of m and n), would be next to impracticable.

(8.) In the Philosophical Transactions for 1814, I pointed out, (I believe for the first time), the possibility of expressing the sum of the series

$$\frac{1}{1^{2x+1}} - \frac{1}{3^{2x+1}} + \frac{1}{5^{2x+1}} - \text{\&c.}$$

by means of the transcendent π and the numbers of Bernouilli alone. The following demonstration of this truth will afford a remarkable instance of the use of the numbers comprised in the form $\Delta^m 0^n$, in what concerns the transformation of series. Indeed many reasons conspire to recommend the introduction of these numbers into analysis, in the place of those of Bernouilli. Simplicity of expression, and facility of transformation, are always to be aimed at, and would be attained in the highest degree by this substitution. We ought, too, to add, that the latter numbers are expressible with ease and neatness, in terms of the former, an advantage by no means reciprocal.

The series in question being denoted by S, Euler has proved that $S = \left(\frac{\pi}{2}\right)^{2x+1} \times \frac{1}{2}$ the co-efficient of t^{2x} in the developement of sec t

Now $\sec t = 2\left\{(e^t)^{\sqrt{-1}} + \left(\frac{1}{e^t}\right)^{\sqrt{-1}}\right\}^{-1}$ and, applying our formula (A), we find for the above co-efficient

$$\frac{2}{1.2.\ldots.x}\left\{(1+\Delta)^{\sqrt{-1}}+\frac{1}{(1+\Delta)^{\sqrt{-1}}}\right\}^{-1}\cdot 0^{2x};$$

that is, by the transformation (F), writing $\sqrt{-1}$ for n,

$$\frac{2\,(-1)^{x}}{1.2.\ldots.x}\times\left\{(1+\Delta)+\frac{1}{1+\Delta}\right\}^{-1}0^{2x};$$

so that we have

$$S=\frac{\left(\frac{\pi}{2}\right)^{2x+1}}{1.2.\ldots.x}\times\frac{1+\Delta}{1+(1+\Delta)^{2}}0^{2x}. \qquad \text{(G)}$$

It remains to transform this latter factor into numbers of Bernouilli. Now,

$$\frac{1+\Delta}{1+(1+\Delta)^{2}}=\frac{(1+\Delta)^{2}}{(1+\Delta)\left\{1+(1+\Delta)^{2}\right\}}$$

$$=\frac{1}{2\,(1+\Delta)}\left\{1+\frac{(1+\Delta)^{2}-1}{(1+\Delta)^{2}+1}\right\}$$

$$=\frac{1}{2\,(1+\Delta)}+\tfrac{1}{2}.\frac{(1+\Delta)-(1+\Delta)^{-1}}{(1+\Delta)^{2}+1}$$

Now $\frac{1}{1+\Delta}0^{2x}=1$ by (D): And we have therefore, for the value of the factor in question,

$$\tfrac{1}{2}+\tfrac{1}{2}\cdot\frac{(1+\Delta)-(1+\Delta)^{-1}}{(1+\Delta)^{2}+1}0^{2x}$$

$$=\tfrac{1}{2}+\frac{2^{2x}}{2}.\frac{(1+\Delta)^{\frac{1}{2}}-(1+\Delta)^{-\frac{1}{2}}}{(1+\Delta)+1}0^{2x}, \text{ (by equation F)}$$

$$=\tfrac{1}{2}+\frac{2^{2x}}{2}.\frac{(1+\Delta)^{\frac{1}{2}}-(1+\Delta)^{-\frac{1}{2}}}{2+\Delta}0^{2x}$$

Again, it is demonstrated in the paper above referred to, in Phil. Trans. 1816, that we have universally, whatever be the form of f or the value of k,

$$(1+\Delta)^{k}.\,f(1+\Delta)\,0^{x}=f(1+\Delta)\left\{k+0\right\}^{x}$$

the second member being supposed developed in powers of 0, and the operation denoted by $f\,(1+\Delta)$ being performed on each power so arising: for x put $2\,x$, for k, $\frac{1}{2}$ and $-\frac{1}{2}$ in succession, and for $f(1+\Delta)$, $\frac{1}{2+\Delta}$, and our expression becomes,

$$\tfrac{1}{2} + \frac{2^{2x-1}}{2+\Delta}\left\{(0+\tfrac{1}{2})^{2x} - (0-\tfrac{1}{2})^{2x}\right\}$$

$$= \tfrac{1}{2} + \frac{2^{2x-1}}{2+\Delta}\left\{\frac{2x}{1}0^{2x-1} + \frac{2x(2x-1)(2x-2)}{1.2.3}0^{2x-3} + \&c.\right\}$$

But we have seen that $\frac{1}{2+\Delta}0^{2x-1} = (-1)^x \frac{2^{2x}-1}{2x}B_{2x-1}$ (by the transformation E); and for x writing $x-1$, $x-2$, &c. and substituting in the above expression, we obtain for our final value of S

$$\frac{\left(\frac{\pi}{2}\right)^{2x+1}}{1.2\ldots.2x}\left\{(-1)^x + \frac{2^{2x-1}(2^{2x}-1)}{1}B_{2x-1}\right.$$
$$\left. - \frac{2x(2x-1).2^{2x-3}(2^{2x-2}-1)}{1.2.3}.B_{2x-3} + \&c.\right\}$$

which is the expression referred to. But the value in (G), without any transformation, is at once simpler as a symbolic representation, and easier to reduce into numbers.

(9.) Let us now consider the series

$$\varphi(\theta) = A_0.f(0) + A_1.f(\theta) + A_2.f(2\theta) + \&c.$$

and endeavour to discover, by direct investigation, all the possible corresponding forms of the co-efficients A_0, A_1, &c. and the function $f(\theta)$, which shall render $\varphi(\theta)$ equal to a rational integral function of θ, or

$$\varphi(\theta) = a + b\theta + c\theta^2 + \ldots.k\theta^n.$$

For this purpose we must develope $\varphi(\theta)$ in powers of θ, and the co-efficient of any indeterminate power, θ^{2x}, being equated to zero with the annexed condition $x > n$ will furnish the condition which resolves the problem. Suppose then

$$F(t) = A_0 + A_1 t + A_2 t^2 + \&c.$$
$$f(t) = a_0 + a_1 t + a_2 t^2 + \&c.$$

and we shall readily see that the co-efficient of θ^x, being the sum of those in each of its separate terms, will be

$$a_x \times \left\{A_0.0^x + A_1.1^x + A_2.2^x + \&c.\right\}$$

Now this, as we have already seen, is expressed by a_x. $F(1+\Delta)0^x$, hence we must have

$$a_x \times F(1+\Delta)0^x = 0;\ [x > n].$$

There are three ways of satisfying this equation, 1st, By supposing a_x itself to vanish for every value of x greater than n; 2dly, By supposing $F(1+\Delta)0^x$ to do so; and, 3dly, By supposing the former of these functions to vanish for some value of x, as, for example, the alternate odd or even, while the latter vanishes for the others, (as the even or odd), or any other such disposition. The first hypothesis it is not necessary to dwell on, as it gives $f\theta$ a rational integral function of θ, and therefore the value of $\varphi(\theta)$ is resolvable into several series, whose sums may be separately ascertained by (4), which is a particular case of this. The second will, on a short examination, appear to be contradictory to the previous supposition that $F(t)$ is developable in positive powers of t; and there remains only the third method of verifying our equation of condition.

(10.) Suppose, therefore, we first assume

$$a_{2x-1}=0;\ F(1+\Delta)0^{2x}=0;\ [x>n];$$

the former gives $f(\theta)=$ any even function of θ (such as $\cos\theta$, $\sec\theta$, &c.) provided only it be developable in powers of θ. The latter gives $F(e^t)=$ (any odd function of t) $+$ R (t) where R (t) represents a rational integral function of t of n dimensions, that is

$$F(e^t)=\psi(e^t)-\psi(e^{-t})+R(t)$$

or

$$F(t)=\psi(t)-\psi\left(\frac{1}{t}\right)+R(\log t)$$

where $\psi(t)$ denotes an arbitrary function of t. In this case, then, we have

$$F(1+\Delta)0^{2x}=\left\{\psi(1+\Delta)-\psi\left(\frac{1}{1+\Delta}\right)\right\}0^{2x}$$
$$+R(\log 1+\Delta)0^{2x}$$

The former part of this expression, as I have elsewhere demonstrated, vanishes, whatever be the form of ψ or the value of x, and we therefore have

$$F(1+\Delta)0^{2x}=R(\log 1+\Delta)0^{2x}$$

and therefore

$$\varphi(\theta)=a_0.\,R(\log 1+\Delta)0^0+a_2.\,R(\log 1+\Delta)0\,\theta^2+\&c.$$

But if we take

$$R(t)=p_0+p_1t+\dots p^n t^n$$

we shall find by our general formula (B)

$$R\,(\log 1+\Delta)\,0^0=p_0\,;\quad R\,(\log 1+\Delta)\,0^2=1.2.p_2,\ \&c.$$

wherefore,

$$\varphi\,(\theta)=a_0\,p_0+1.2.\,a_2\,p_2\,\theta^2+\ldots.\,1.2\ldots..\,n\times a_n\,p_n\,\theta^n\,; \qquad \text{(H)}$$

because in this case n must be an even number.

We may know at once whether any assigned form of F (t) satisfies the above condition, without actually determining the form of ψ, by regarding the equation

$$\psi\,(t)-\psi\left(\frac{1}{t}\right)=F\,(t)-R\,(\log t)$$

as a fundamental equation for finding ψ and enquiring the condition of its possibility, which will appear to be

$$F\,(t)+F\left(\frac{1}{t}\right)=R\,(\log t)+R\,(-\log t)\,; \qquad \text{(K)}$$

and if on substitution in the first member it be found that there does not result either zero, or an even rational integral function of log t, the form assigned to F is contradictory. If, on the other hand, such a function does result, it is satisfactory; and R (log t) may immediately be had by taking half this result.

(11.) In exactly the same manner, if the even values of A^x vanish, and the odd ones of $F\,(1+\Delta)\,0^x$, we have $f\,(\theta)=$ any function developable in odd positive powers of θ; and

$$F\,(t)=\psi\,(t)+\psi\left(\frac{1}{t}\right)+R\,(\log t),$$

which gives for the condition of possibility

$$F\,(t)-F\left(\frac{1}{t}\right)=R\,(\log t)-R\,(-\log t)\,; \qquad \text{(L)}$$

any odd rational integral function of log t, the half of which being taken, gives R (log t) and of course the co-efficients p_1, p_3, &c. which found, we have (n being odd in this case)

$$\psi\,(\theta)=1.\,a_1.\,p_1+1.2.3.\,a_3\,p_3+\ldots.\,1.2\ldots.\,n\times a_n.\,p_n\,; \qquad \text{(M)}$$

(12.) Other cases, though of less analytical neatness, might easily be devised; but it will suffice to exemplify these by one instance. Let then

$$F\,(t)={}^nL\,(1+t)=\frac{t}{1^n}-\frac{t^2}{2^n}+\frac{t^3}{3^n}\ \&c.$$

and we have

$$\varphi\,(\theta)=\frac{f(\theta)}{1^n}-\frac{f(2\,\theta)}{2^n}+\frac{f(3\,\theta)}{3^n}-\&c.$$

and making all the necessary substitutions and reductions we have,

$$\varphi(\theta) = {}^{0}\mathrm{L}(2).\,a_n\theta^n + {}^{2}\mathrm{L}(2).\,a_{n-2}\theta^{n-2} + \&c.$$

where, n being even, $f(\theta)$ must be an even function, and the last term of $\varphi(\theta)$ will be ${}^{n}\mathrm{L}(2).\,a_0$; but if n be odd then $f(\theta)$ must be an odd function, and ${}^{n-1}\mathrm{L}(2).\,a_1$ will be the last term. This is in fact precisely the theorem demonstrated in Phil. Trans. 1814.

Although *when the series $\varphi\,\theta$ is susceptible of such a sum* as that under contemplation, the above investigation will invariably give it; yet the results it leads to (though no apparent error can be detected in the analysis,) are in some cases at variance with those afforded by other methods, and this indicates the necessity of some criterion to distinguish *a priori* whether any contradiction is involved in supposing it so susceptible. It is easy to assign forms to $f(\theta)$, (such for instance as $\frac{1}{1+\theta^2}$), which shall be alike susceptible of developement in positive and negative powers of θ, and it is requisite in many cases to take into consideration the negative developement in order to get the true sum. But to enter into any discussion on this very interesting part of the subject, would far exceed the proper limits of the present essay.

SLOUGH, *January* 9. 1819.

ART. VII.—*On the Application of Oars to Steam-Boats.* By Mr RICHARD WHYTOCK, Edinburgh.

IT is impossible to observe the motion and the progress of the latest constructed of our Steam Boats, without being convinced, that the art of navigation by means of such vessels is yet in its infancy. The disadvantages attending the present mode of applying the power to the water, for the purpose of propelling the vessel, seem to be very generally acknowledged; but no more effectual method has yet been put in practice.

The first objection which occurs to the use of wheels for propelling the vessel, is, that there is a great waste of power. The wheel, at every point of its circumference but one, is either ascending or descending. Each of the arms has to be immersed at a considerable expence of power, and the effect of its application to the water, in this direction, would be, to lift the vessel out of the water, as much as to push it forward upon the surface, were it not that the force necessary to lift another of the arms out of the water, is equal to that which is required to immerse the former. In other words, the tendency which the descending arm has to elevate the vessel, is counteracted by the operation of the ascending arm, which tends to depress it. In short, the space in which the revolution of the wheel is of any use in forwarding the vessel, is very small. One-fourth of the power, steadily applied in a horizontal direction, would produce greater effects.

The next disadvantage attending the use of wheels is, that the force is applied to the water *too close to the sides of the vessel.* It is true, that this is an objection common to all the different methods yet put in practice; but in the case of wheels, especially as they are generally placed nearly as far forward as the *bow* of the vessel, the effect is to bring a current against the head of the vessel, which impedes its progress, and occasions an incalculable waste of power.

I am aware, that many plans may be, and have been resorted to, in order to obviate the first of these objections, and to substitute a direct instead of a circular motion. One of these is very ingenious. It consists of a flat chain passing over *two* wheels; and upon this chain are raised small boards standing on edge. As the chain passes in one direction, the boards are immersed in the water, and return in the opposite direction out of the water; the two wheels around which they pass being partially under water. The whole of the impulse given by these boards from the lower part of one wheel to the lower part of the other, is direct and effectual. Such a plan, of course, is only applicable to smooth water, because the force of waves would destroy any slight apparatus before it had been long in motion. It is of far more consequence to discover a method by which the sea could be navigated with greater safety, at least around the shores of our own island.

The second objection which I have stated against the use of wheels, is more radical and important than the first. I do not know whether it has been taken into consideration, that, by placing the wheel or other propelling apparatus too near the side of the vessel, a most important advantage has been lost, and a principle which ought to have been very obvious, has been overlooked or neglected. Not only has a resisting force been invited and called into action, but a powerful auxiliary force has been allowed to remain unemployed. Although this force, to which I refer, has not been called into action in aid of the progress of steam-boats, yet the motion of every row-boat, since the oar was first invented, has been powerfully accelerated by its influence. It must have appeared strange to every accurate observer, that the rower should be able to exert his strength so effectually as he does, when it is considered that he holds in his hand the short end of the oar or lever. Instead of having the benefit of any of the mechanical forces to assist him, he has the most powerful of these operating against him. This disadvantage would long ere now have proscribed the use of the oar, and occasioned the substitution of some other instrument, were it not that the operation of this force, to which I am about to direct the attention of the reader, has, although unobserved, the effect of overcoming the disadvantage, and of counterbalancing the loss of power occasioned by the use of the *reversed* lever.

When the rower takes hold of the water by dipping his oar, a double effect is produced. There is first a motion communicated to the boat, equal to what would have been communicated, had he taken hold of some fixed object, with the point of his oar, and exerted the same strength. But, besides the impetus which is given to the boat by the pressure upon the point under the fulcrum of the lever, technically speaking upon the *thaul-pin*, (and which impetus would be nearly the same whether the oar took hold of the water, or whether it took hold of a fixed object at the same distance from the boat), there is another force called into action *by the stroke in the water*, which would not be obtained by resting the point of the oar upon a fixed object. This force is neither more nor less than a current occasioned by the stroke of the oar. By this stroke a current is formed in a direction contrary to the motion of the boat in the first instance; but a necessary consequence of this is, that another current is formed, running in favour of the boat, and in which the boat is placed. Plate I. Fig. 2., will show the direction of the currents occasioned by the stroke of an oar on each side of a boat. In the first place, The action of the oar in the water produces a sort of vacuum a-head of the boat, which the head of the boat, as it were, advances to supply. The same stroke occasions a current in the water, which turns a-stern of the boat, pushes it forward, and carries it along with it, as long as the effect of the stroke continues to occasion any motion in the water. Unless this way of accounting for the powerful effects of the oar be satisfactory, I humbly conceive, that any intelligent correspondent, who can give a better explanation of the difficulty, will confer a favour on the public by so doing. It must appear very strange, that a boat rowed by a single person should so powerfully breast the waves, and rush along the watery element, when all the power which he can employ, at the further extremity of the oar, cannot be equal to one-tenth part of the strength exerted.

If the effect of the current in propelling the boat be so important, it is certain that this is a power hitherto neglected in navigation by steam; on the contrary, the power of the current has been made one of the greatest obstacles in retarding the progress of the vessel, inasmuch as, from the situation in which the wheels are placed, the current is brought right against the prow, and has the effect of counteracting, in a great measure, the efforts of the labouring engine within, and occasions a needless waste of mechanical force.

I only intend farther to observe, that it appears to me, that the most effectual way to obtain the advantages of the currents described, is to have recourse to the rejected oar. And lest any one should condemn this paper as too speculative, I shall only allude generally to the way in which I believe this could be aptly and effectually done; and reserve the full description of the apparatus to a future occasion, or to be offered in some other shape, to those who are directing their attention and capital to the improvement of this new and important branch of navigation.

I am aware that the power of steam has been applied to the oar, but never, so far as I know, with a view to produce the effects I have described; but, on the contrary, from the direction in which it has been applied to the water, it could produce none of these favourable effects; that is, it was made to take hold of the water too near to the side of the vessel, and was thus attended with the same disadvantages which arise from the use of wheels. In the application of the oar, however, to the steam-boat, it would be necessary to use it exactly in the way in which it is used by the rower, and to make it touch the water in the same direction. An attentive observation of his motions will suggest the proper application of the power. He never looks where he is to dip his oar; he never calculates how deep he is to immerse it. Whether the water is rough or smooth, he takes the same hold of its surface. If a wave rise and meet the descending oar, it dips only so far as to take the proper hold of it. If the next stroke fall between two waves, the oar descends so far as still to reach the water, and to dip the proper depth. This is effected solely by his balancing the oar, so as to reduce its weight at the extremity to little more than the specific gravity of the water; and he soon learns to adjust this by the pressure of his hand *downwards*, at the same time that he makes the pull in a horizontal direction.

It will be evident from this, that the only way in which the oar could be used under the power of steam, and applied on any other than smooth water, would be in the way of having its specific gravity adjusted, so as always to take the same hold of the water, whether the rising wave met it, or the receding surface required it to descend to a greater depth.

An apparatus of the most simple kind would be sufficient to adjust the weight of the oar, so that it should always be sunk in the water to the depth required. Within the vessel balance-weights might be used, to reduce the weight of the extremity of the oar, as represented in Fig. 3. Plate I. Springs would have the same effect, and might be more surely applied. But it is needless to go into the detail of the necessary machinery. All that I propose is, to communicate the idea, and to suggest the principles which, I conceive, have been overlooked. And I am convinced that the whole apparatus might be made more simple than that which is now in use.

The advantages which would attend the use of oars would be, that they could be singly replaced, even without stopping the machinery. They could be elevated into a perpendicular position, when it was intended to stop the vessel for a short time, and the engine still be allowed to play. And when necessary to pass close to another vessel, the same manœuvre could be practised. And, finally, when a certain degree of impetus had been given to the vessel, such an apparatus would not act in the way of counteracting this, the bottom of the vessel being left perfectly clear of all incumbrance. I have no hesitation in saying, that were this plan adopted, there would be a most material saving of power, and the velocity with which the vessel would plough the waves, would exceed, in an inconceivable degree, the greatest feats of the kind yet performed.

Fig. 3. Plate I. represents the balanced oar ; A is a section of the side of the vessel ; B the end of the oar to which the power would be applied ; C the pivot upon which the oar would turn ; D the joint of the oar ; E the lever by which the oar would be elevated, and its weight adjusted ; F the pulley over which the cord would pass, and G the weight by which the oar would be balanced. Instead of a weight, a strong spring might be employed, such as is shewn at H.

Along with the drawings which accompany this article, I have given a sketch of a screw, (See Fig. 4. Plate I.), which I constructed five or six years ago, with a view to a trial of its efficacy in propelling a vessel. Although I was prevented at that time from completing the experiment, enough was ascertained to warrant a trial upon a more expensive scale, as soon as time and opportunity should permit. The following is the way in which the screws that I used were constructed.

A cylinder of wood 6½ feet long, and 2½ inches thick, was divided by means of a cord in a spiral direction. The cord made 3½ turns in the length of the pole. The sole use of this cord was to show the direction of the spiral line, until it was marked out and pierced with a succession of holes, at distances of about two inches between each. Into these holes slender rods were fixed at right angles from the cylinder. The skeleton of the screw being thus formed, a piece of soft twine was fixed to the first of these rods, close to the pole, and carried to the second, around which it was made to turn once, and then to the third, and in like manner along the whole of the rods. Then it was brought back in the same manner in an opposite direction. By repeating this process, a web was formed from the cylinder to the points of the rods; and thus the form of the screw which I reckoned best adapted for the purpose was obtained. The rods being ten inches long, and the cylinder 6½ feet, and the screw consisting of 3½ turns, the mean angle at which the screw pressed upon the water, was one of 45 degrees. Pitch was then applied, to give a solid body to the screw thus formed, and the web exactly resembled that of a duck's foot.

Having obtained the measurement, and the exact shape of a boat which lay at one of the lochs in the neighbourhood of Edinburgh, I had a frame made to support two screws, and of a shape and size to fit the boat; because without getting a boat made for the purpose, I could not apply one screw alone. As soon as the screws were let down into the water, and the boat was pushed off by means of the boat-hook, the upright handles, with which the screws were intended to be put in motion, began to turn round in the opposite direction; so that by this alone, the way in which they would operate became evident, although it was only the intended motion reversed. When force, however, was applied to turn round the handles, the breadth of the screws, and their too deep immersion in the water, rendered it necessary to apply a degree of pressure which did not consist with their delicate structure, and the bevelled wheels, upon the axis of the cylinder, not having been sufficiently fixed, gave way, and parted from the axle, which occasioned the experiment to be put off, until they could be properly adjusted and made secure. Next day, however, I was denied the farther use of the boat, and obliged to relinquish all further experiments with the same apparatus, as it was made to fit this particular boat only. Perhaps this description of the invention and experiment, may induce some person in more favourable circumstances to give a full trial to this scheme.

EDINBURGH, *October* 1. 1819.

Art. VIII.—*On Peat.* By John MacCulloch, M. D. M. G. S. Lecturer on Chemistry to the Board of Ordnance, &c. Communicated by the Author.

So much has already been written on this interesting substance, that it is scarcely possible at the present day to add any thing to the history of its origin, or to the description of its various appearances. The natural history of peat has perhaps, on the contrary, been occasionally rendered somewhat obscure by superfluity of discussion, while its chemical nature has either been misapprehended, or involved in mystery, from causes which need not here be noticed, but which will be sufficiently apparent to those who may be inclined to read all that has been written on this subject. It does not appear difficult to place the latter in a more intelligible light, by recurring to a few simple principles, in which some interesting analogies are also involved; while the former may perhaps also be simplified by a condensation and arrangement of the facts which are obvious to the examination of all, and which have been more or less accurately described by numerous observers. A sketch of the natural history of this substance is at any rate an indispensable preliminary to the few observations which it is here proposed to offer on its chemical nature.

The concurrence of a certain degree of moisture, and of a moderate temperature, appears necessary to regulate the decomposition of vegetables, so as to lead to the formation of peat. But the first condition admits of great latitude, as it is formed not only under water, but on drained declivities, in situations and climates that are subject to a very moderate proportion of rain. It is also produced under a great range of temperature; but the observations hitherto recorded, have not enabled us to determine at what degree of heat it ceases to be generated. It is merely known, that in warm climates the decomposition of vegetables is so rapid, as to prevent its formation; and that, in these, it is therefore found only at high elevations, while, in the cold and temperate climates, it abounds even at the level of the sea.

The quality of peat varies principally according to the different situations in which it is formed, as these differ in the degree of drainage and of temperature, and in the nature of the vegetables which they produce. Hence agriculturists have distinguished several varieties, which have, however, been sometimes also named from differences of texture, at others from differences of situation. The former distinctions have been founded either on the more or less perfected state of the process, or on accidental circumstances, which will hereafter be apparent. The whole of these varieties may be included in the following divisions: namely, Mountain, Marsh, Forest, Lake, and Marine, Peat. To these ought to be added transported peat, which, although of very partial occurrence in this country, appears to abound in Holland, and in other parts of the continent of Europe.

These several essential varieties occasionally present many inferior distinctions of quality and aspect, arising either from the nature of the plants which have contributed to their formation; from the varying extent to which the process has been carried; from intermixture of character, dependent on the variable state of drainage or other causes, or from the alternation or admixture of transported earth or of shells. In some instances, even in situations very different, they approach so nearly in character as to be undistinguishable; and this happens more particularly in the peat of lakes and in that of marshes, and in those cases where the process is most complete.

In general, peat forms a single superficial stratum, lying either on the solid rock, as in the islands of North and South Uist, Lewis, and the remainder of that chain, or on the alluvial soil which, in other places, is found above the fundamental rock. In other cases it is found to alternate with sand and gravel, with clay, or with shell marl; while, in a few instances, it is found at considerable depths, buried under a thick bed of clay, or of other alluvial soil. The alternations of sand and gravel occur either on sea-shores, at the estuaries of rivers, or their termination in lakes, or in other situations where large quantities of these materials are carried down by rivers, so as for a time to cover the plain, and destroy the process of vegetation. In those cases where large deltas are formed or bays are filled up, the deposition of earth continues to proceed, till the original peat becomes buried to a considerable depth, and as such plains are generally brought into cultivation, it is never again renewed. Alternations or deposits of marl are only found in those situations where the peat has been generated in a lake; and they offer a criterion, not only of the former existence of lakes which have long since disappeared, but are capable of determining, to a certain degree, the depth which these once possessed.

Mountain peat is not limited strictly to mountainous declivities, but is found in all situations where the drainage is considerable. This variety is commonly loose in texture, and its average thickness may be estimated at a foot. It rarely amounts to two feet, and often does not exceed as many inches. As an article of fuel it is of little value, when compared to the other varieties, from its thinness and want of compactness; but it is more interesting in an agricultural view, from the great extent of surface which it occupies in Scotland, and from the comparative facility with which, in low situations, it is brought into cultivation. The dry moor lands are generally covered with this variety, or with a variety intermediate between it and the more compact peat of marshy and ill drained situations. The plants which principally conduce to the formation of mountain peat are the following:

Erica cinerea.
    vulgaris.
    tetralix.
Myrica gale.
Empetrum nigrum.
Tormentilla erecta.
Arbutus uva ursi.
Vaccinium vitis idæa.
Juniperus communis.
Polytrichum commune.
Lycopodium clavatum.
Lichen rangiferinus.
Nardus stricta.
Scirpus cæspitosus.
Juncus squarrosus, together with various grasses, chiefly belonging to the genera Aira, Agrostis, and Carex.

Marsh peat is chiefly formed in flat undrained lands, or on the margins of lakes, while it is also produced during the last stage of the formation of lake peat, with which it is therefore often found united, constituting the upper surface of the more compact variety which has been generated under the water. It is often found occupying extensive plains, and presents a great variety of aspect. These varieties depend chiefly on the very various state of drainage, arising either from situation, or from difference of season; and as such extensive plains often retain water very unequally, the same tract will often be found to present considerable diversity of character. In some situations it is semifluid beneath, and covered with a matting of tenacious and half decomposed vegetables, or else it is interspersed with partial spots of the same nature, maintained by the firmness of the heath, or of the rushes which have established themselves in those places. In other situations it is intermixed in minute patches with mountain peat, according to peculiarities in the form of the surface, capable of determining the formation of these different varieties.

Marsh peat occasionally forms a very imperfect stratum only, the roots of the rushes and grasses retaining much of their original firmness, in which case it is sometimes known by the name of *Rush-turf*, while, in other cases, a stratum of perfect peat is found beneath it; an occurrence which takes place when a trembling bog has been accidentally drained; or when, by the gradual accumulation of the peaty soil, the level has been so far raised as to cause a constant and natural drainage. It is in this species of peat that the *Sphagnum palustre* forms so conspicuous an ingredient, and this plant is indeed, from its nature, limited to the peculiar situations in which marsh-peat is formed. The other plants, which chiefly contribute to its formation, are included in the following list:

Erica vulgaris.
    tetralix.
Myrica gale.
Vaccinium oxycoccos.
Eriophorum polystachium.
    vaginatum.
Schœnus albus, and others of this genus.
Scirpus cæspitosus, and others of this genus.
Pedicularis palustris.
    sylvatica.
Orchis maculata.
    conopsea.
Juncus, various species.
Carex, various species.
Aira aquatica.
Aira cæspitosa.
Festuca fluitans.
Caltha palustris.
Hydrocotyle vulgaris.
Lysimachia tenella.
Menyanthes trifoliata.
Ranunculus flammula.
Comarum palustre.
Narthecium ossifragum.
Pinguicula vulgaris.
Drosera longifolia.
    anglica.
    rotundifolia.
Triglochin palustre.
Phalaris arundinacea.
Arundo phragmites.
Some of the Equiseta.

The formation of *Lake peat* is of a much more complicated nature than that of the two preceding kinds, and is moreover rendered additionally interesting, by its connection with that important set of changes on the surface, which consists in the obliteration of lakes, and the increase of dry land. From the remarks immediately preceding, it will appear, that it is intimately connected with the generation of marsh-peat; since, during its whole progress, it is attended by, and finally terminates in this variety.

There are thus two distinct modes in which peat is formed in lakes, and, in each, a distinct set of plants is engaged. There is, however, a certain point at which these unite, and at which both processes are combined in producing the result by which the water is ultimately excluded, and a mass of solid materials is at length found occupying the place which it once possessed.

In the shallow parts of lakes are found numerous subaquatic plants, which, in summer, flower at the surface, subsiding to the bottom after that process is completed. By the annual death of portions of these, a stratum of peat is formed at the bottom of the water, where this process is also constantly going on by the successive decomposition of the Scirpus acicularis, Lobelia dortmanna, Subularia aquatica, and other plants, which form a continuous mat of verdure, where the water is sufficiently shallow to admit of their growth. The death of fresh-water shell-fish, and the deposits of earth and sand brought into the lake by rivers, assist still farther in shoaling the water, and in thus affording a lodgment to another class of plants, which advance from the margin in succession, according to their several propensities to thrive in greater or less depths, or on the half drained and marshy meadow by which the lake is bounded.

In other cases, no distinct bed of peat is produced from the subaquatic plants, but the whole process is the result of a gradual extension of the margin. This may readily be examined in those lakes of which the interior declivity is gentle, and at those points where deltas are formed by the entrance of streams. The growth of Arundo phragmites, Scirpus lacustris, Lobelia dortmanna, and other plants, here serves to detain much of the sand and earth which would otherwise be carried forward into the deeper parts of the lake, and thus gradually affords a place first to the rushes and grasses which flourish in inundated soils, and lastly, to the various plants which, in succession, grow in marshy grounds of different degrees of moisture.

Thus a stratum of peat is gradually formed from the original margin inwards, covering, by its extension, the bottom of the lake, till, in certain cases, the water is entirely excluded, and the whole becomes a peat-bog, or, as may happen in other circumstances, a meadow. Under such a stratum of peat, the shells which have been deposited in the course of years, are at length consolidated into the marl beds, formerly noticed, which are so frequent under the flat peat-bogs of the Highlands.

These are often of such an extent and thickness, as to form valuable quarries, if this name may be adopted, for the purposes of agriculture; the calcareous manure which they afford, being of the best quality. Many mossy lands have thus acquired a value which was little foreseen, and by which the proprietors or purchasers have very unexpectedly profited. The discovery of these marl-pits has generally been the result of accident, or of the excavations used for procuring fuel; very few of the farmers or proprietors being aware of the true nature and origin of these deposits. A more general diffusion of that knowledge among them, would lead to the discovery of marl in many parts of the Highlands, where it is as yet unknown, and where calcareous manure is, from its rarity and distance, extremely valuable. As the shell-fish, which contribute to its formation, exist even in very small collections of water, it may often be found in the mountain peat-mosses of very limited extent, as well as in the larger, which have resulted from the partial or total obliteration of considerable lakes. It may be sought for with a prospect of success, in all those mosses which are bounded by rocky or elevated margins, or which occupy basin-shaped cavities. Some of these still give passage to the river which once flowed into the original lake, and which has, by its deposits of earth, contributed to fill the cavity; while others, which give passage to no river, have been produced by the gradual increase of vegetation from the margin in the mode just described. Experience in the forms and disposition of existing lakes and pools, will easily guide the eye in the selection of those spots where marly deposits may occasionally be expected. It must, however, be added, that marl is sometimes found on declivities, mixed with, and buried under mountain-peat. But these very singular deposits are rare, and the produce of terrestrial shells, of which an account was given by the writer of this article in a paper on Glen Tilt, published in the Geological Society's Transactions.

It is easy to see how lake-peat may alternate with strata of clay, and of gravel and sand. These have been the result, as at the estuaries of rivers before noticed, of occasional floods, carrying with them so large a quantity of earth as to suffocate and destroy for a time the process of vegetation; and it is easy to conceive how the occasional addition of such transported materials, might, for a certain time, impede the re-establishment of a vegetating surface, so as to form an earthy stratum of considerable depth. It is also easy to understand how the gradual addition of earth, in a quantity insufficient to destroy vegetation, may, instead of peat, lead to the production of an ordinary vegetable soil, and how the margin of a lake, in the act of filling, will, instead of a peat-bog, become a fertile meadow.

In concluding this sketch of the formation of lake-peat, it is interesting to observe the simplicity and certainty of the processes by which water is converted into land in the interior of a country, as it is near the marine estuaries of rivers.

The plants which chiefly contribute to the formation of this kind of peat, are the following, and they are separated, in some measure, according to the regions which they occupy in the water or on its margin.

- Conferva bullosa.
- Lemna minor.
  - trisulca.
- Nymphæa alba.
  - lutea.
- Potamogeton natans.
  - heterophyllum; and others of this genus.
- Chara vulgaris.
- Hippuris vulgaris.
- Callitriche verna.
  - autumnalis.
- Myriophyllum spicatum.
  - verticillatum.
- Ceratophyllum demersum.
- Utricularia vulgaris.
  - minor.
- Sparganium natans.
  - erectum.
- Ranunculus aquatilis.
- Hydrocharis morsus ranæ.
- Arundo phragmites.
- Scirpus lacustris.
- Lobelia dortmanna.
- Scirpus acicularis.
  - setaceus; and others.
- Subularia aquatica.
- Isoetes lacustris.
- Alisma plantago.
  - ranunculoides; and others.
- Sagittaria sagittifolia.
- Butomus umbellatus.
- Acorus calamus.
- Phalaris arundinacea.
- Poa aquatica.
- Juncus conglomeratus.
  - effusus; and others.
- Schœnus mariscus; and others.
- Menyanthes trifoliata.
- Comarum palustre.
- Some Equiseta.

It is unnecessary to add to this enumeration the Sphagnum palustre, and some other plants which were before mentioned under the head of marsh-peat.

The next division is that of *Forest-peat.* It has often been asserted, that all peat was the produce of decayed woods; but the preceding remarks render it unnecessary to enter into a formal discussion on the unfounded nature of that opinion. Even those peat-bogs which now cover the decayed trunks and roots of trees, and which have been supposed to have originated in their destruction, owe great part of their bulk to the growth and decay of plants subsequent to the period of their fall, and are now increasing by a continuation of that process which forms the peat of marshy or of wet moor land. During the growth of a forest, in favourable situations, a stratum of peat is formed by the accumulation of decaying leaves and branches, and by the death and renovation of the plants which grow under their shade. Where, in the lapse of time, the trees of these forests have fallen, whether from the effects of age, from storms, or from other causes, a certain portion of the wood decays, and adds to the original deposit; while the growth of additional plants of different kinds, perpetuates the process. In these cases, the smaller branches, and even the larger, being exposed for a longer period to the effects of air and water united, and being, from their size, more susceptible of decomposition, are ultimately converted into peat; while, in a few situations, even the trunks disappear. Where, on the contrary, the growth of the peat stratum has been so rapid as to cover the trunks, so as to exclude the alternate action of air and water, these remain for a long period unchanged, and are often dug up unaltered, so as even to be applicable to the ordinary purposes of timber. Oak, in such circumstances, is well known to acquire a black colour, and to become valuable for the purposes of the cabinet-maker. As the roots are soonest and most effectually protected from the causes of decay, they are generally found unchanged, even when the trunks have entirely mouldered away. It has been supposed that peat possessed some mysterious antiseptic properties, by which this effect was produced; but it differs in no respect from that which equally occurs where wood is so far buried, as in the case of piles, as to be excluded from the influence of the air, or from alternations of dryness and moisture.

Although the submerged wood of peat-bogs thus continues often unchanged for a long period, in other cases it undergoes a chemical change, without loss of texture, and acquires the peculiar properties of peat. It will hereafter be shewn, that a longer continuance of the same action of water produces an incipient bituminization, and that time alone is probably required to convert such wood into lignite, or into a substance resembling brown coal, surturbrand, or even jet; products, of which the peculiarities are in some measure owing to collateral circumstances, which it is unnecessary at present to consider.

It is scarcely necessary, in concluding this subject, to remark, that forest-peat must vary materially, according to the proportions in which wood and the ordinary marsh plants enter into its composition, independently of the numerous other circumstances by which the characters of every variety of this substance are modified.

The trees which in Scotland enter into the formation of forest-peat, are chiefly *oak*, *fir*, *alder*, and *birch*. To these may be added, as more rare, the *ash*, the *roan*, the *hazel*, and different species of *willow*. To enumerate the plants which grow under their shade, or occupy the soil on which they have fallen, would, with a few trifling additions, be to repeat much of the catalogues which have already been given.

It has scarcely been noticed by our writers on this subject, that peat is also occasionally formed on sea-shores, by the death and renewal, in salt-marshes, or in other analogous spots, of those plants which affect maritime situations. Such peat may, however, be found on the shores of the maritime Highlands, and in other analogous places, and it often forms strata alternating with sand, or with the muddy deposits of rivers. It is not uncommon, in those places where the estuary of a considerable river is a sea-loch, and where, by the gradual extension of the shallow shores, from the same causes which operate in shoaling inland lakes, the sea becomes gradually excluded. West Loch Tarbet and Isla, in this country, present, among other places, very accessible and conspicuous examples of this process, in its several stages. In the former spot, it may be seen in a state of great activity, and a considerable accession of land is thus gradually taking place. In Isla, it has long since terminated in the flat tract by which Loch Greinord communicates with the head of Loch-in-daal, and the stratum of maritime peat is here submerged beneath a considerable depth of alluvial soil.

In North Uist, peat is found in analogous situations, appearing, in these cases, to have been generated by those plants which grow in sandy soils, and which have, after a certain time, been overwhelmed by the accumulation of blown sand. The submergence of maritime peat by soil, where the estuary of a river is the sea, is so exactly analogous to that which takes place where a river terminates in a lake, that it is unnecessary to dwell on it. It is equally obvious, that the power which the semi-maritime plants exert in detaining the alluvia of rivers, or the sand of the sea-shore, is similar to that which the common reed and bulrush exert on the shores of lakes, and it is therefore also unnecessary to dwell on this subject. As the marl of fresh-water shells is found alternating with inland peat, so deposites of sea-shells, in various states, are found intermixed with that which is of maritime origin.

The peat formed on sea-shores by the plants that grow in sand, is small in quantity; nor is it always certain that it originates in these plants, even where it is difficult to discover to what others it can have owed its origin. These plants are chiefly the following:

Triticum junceum.
Elymus arenarius.
Arundo arenaria.
Carex arenaria.
Galium verum.
Valantia cruciata.
Thalictrum minus.
Trifolium repens; and various well known grasses.

The plants which grow on the alluvial flats, or in the salt-marshes, are more numerous, and comprise principally the following species:

Glaux maritima.
Juncus maritimus.
Triglochin maritimum.
Aster tripolium.
Schœnus mariscus.
Arenaria peploides.
marina.
Scirpus holoschœnus.
maritimus.
Scirpus triqueter.
Matricaria maritima.
Statice limonium.
armeria.
Artemisia maritima.
Bunias cakile.
Chenopodium maritimum.
Salicornia herbacea.
fruticulosa.

But the most conspicuous and important plant in extending the alluvia of maritime estuaries, is the *Zostera marina,* which forms large submarine plains at considerable depths under the sea, and, by detaining the sand and mud, gradually raises the bottom so far above the high-water mark, as to enable it to afford a place for the plants of the preceding catalogue. By the bulk and extent of its roots, it also serves to form the principal part of the peat stratum which is found on sea-shores.

The several varieties above enumerated, include all the depositions of peat which are found in their natural situations; but another variety remains, which was already mentioned, and which it is necessary to notice, before quitting this part of the subject. It consists of the finer parts of perfect peat, which have been transported by water to cavities capable of detaining them. This transported peat is rare in Scotland, and generally occupies small patches in mountainous land, where it produces a liquid or trembling bog: on the Continent of Europe, it appears to form more extensive tracts, and to be of considerable importance. When drained, it constitutes one of the most solid and perfect varieties of peat.

The progress of change from the living vegetable to peat, is most easily traced in the flat mosses of plains, and may be examined in the deep sections which are made for procuring fuel. In these, a regular gradation may be traced, from the spongy half-decomposed vegetable matter to the solid inorganic peat, in which nearly all traces of the plants have been obliterated. A similar gradation, but less perfect, may be found in mountain-peat; but the progress of the other varieties is, from their peculiar nature, less susceptible of examination. Where the living plants terminate, their roots are found intermixed with the half-decomposed matter, produced by their leaves and fragments, forming a spongy mass. Lower down in the stratum, the pulverized peat is seen mixed with a few fibres or fragments still resisting decomposition. These gradually disappear in the progress downwards, until at length a finely powdered substance alone is found; the process being completed to the eye in the total destruction of all the organized bodies. When this process has occurred on a drained declivity, the pure peat forms the powdery heath-soil used by gardeners for rearing certain plants; where, on the contrary, the soil is wet or inundated, the powder is intermixed with water, which, on being drained, leaves it in a state often highly compacted and firm, producing that peat which is more valuable for the purposes of burning. A variety of modifications result from collateral circumstances or intermediate conditions; the chief of which are, differences in the nature of the vegetables, in the time during which the process has lasted, in the degree of drainage, and its occasional variations, and in the elevation, or other causes, affecting the temperature, or the moisture of the atmosphere.

The commencement of the process is easily traced in the *Sphagnum palustre*, which, in some situations, forms an important ingredient in peat. In this plant, as the lower extremity dies and is decomposed, the upper, like many other mosses, sends forth fresh roots, and extends its offsets; the individual becoming thus in a manner immortal, and supplying a perpetual fund of decomposing vegetable matter. A similar process, although less distinct, takes place in many of the rushes and grasses, the ancient roots and leaves dying, while the existence of the plant is perpetuated by the annual renovation of both. Many other vegetables add to the common stock, by their annual death, their existence being repeated in seedling plants; while others, of a perennial nature, contribute only by the ordinary decay and renewal of their leaves.

It is therefore evident, that the growth of peat is constant, but that it depends, at the same time, on the continuous growth of the vegetable covering. Hence mountain-peat is always increasing while it continues to bear those plants from which it was originally produced; as its state of drainage, and looseness of texture, are such as never to refuse a hold to fresh plants of the same nature, even after the vegetating covering has been completely removed. There are certain cases, however, in which the growth of mountain-peat ceases, the vegetating covering being replaced by plants which, under the circumstances that first produced them, continue to grow, and possess no tendency to form that substance. These cases are interesting to the agriculturist, as they form, in fact, the several processes by which this species of peat is converted into green pasture or into arable land. The pasturage of sheep, the application of calcareous manures, or of clay or sand, burning, and the turning of the surface by agricultural implements, are the chief means by which the vegetation of these soils is exchanged for more profitable plants. To these must be added the growth of larch, under which the original covering is gradually extirpated, and replaced by a green and grassy surface, applicable to the pasturage of cattle.

Although the formation of marsh-peat ceases, when, from the gradual increase of elevation, or from other causes, the bog becomes drained, this substance still continues to be generated, but in a slower manner, by the plants that form it on mountain-declivities.

The formation of forest-peat must be considered to have terminated with the decomposition of the wood which has first fallen, although the process still goes on in a different manner, by the growth and decay of the various plants which occupy the same place. A few cases are however known, where it appears that forests have successively grown and fallen on the same spot, so as to have continued the original process.

The peat of lakes is necessarily completed, when once the water has disappeared; and in a similar manner, that which is formed from maritime plants, ceases to grow, when, by the final exclusion of the sea, the character of the vegetation is changed.

Of the formation of transported peat there is no end, as long as the flow of water from mosses continues, and cavities exist in which the material can be deposited.

As the increase of peat necessarily keeps pace with the growth of the plants from which it is formed, it is evident, that the cessation of the one is implied in that of the other, with the exception of transported peat, which does not directly depend on the same cause. That it may be renovated after cutting, it is therefore necessary that the process of vegetation be renewed where it has thus been suspended. In mountain-peat, it has already been shewn that this takes place naturally, as this variety generally approaches so much towards ordinary vegetable soil, as readily to admit of the lodgment and growth of seeds. But the compact and perfect varieties which are exposed by the operation of cutting, are not thus susceptible of renewed vegetation, as no plant seems willingly to attach itself to peat in this state. But if the pit has been so formed as to admit of the stagnation of water, the process is sometimes renewed by the same series of operations which takes place in lakes; and thus the cavity becomes once more filled with the same material, always, however, distinguishable for a long period by the laxity of its texture. If the exposed surface is drained, no such event follows, but the spot appears to remain for ever naked, and of course incapable of augmentation or renewal, as may daily be witnessed in mountains, where the perfectly formed and compact peat has been either naturally or artificially exposed. This is now well understood; and it has accordingly become a general practice to reserve the superficial covering, and replace it on the bottom, after the peat required for fuel has been removed.

The time required for the production of a given depth of peat has been a frequent subject of inquiry. In some cases, its growth has been found so rapid as to be sensible to the observation of individuals; but, in general, it has been necessary to have recourse to evidence founded on circumstances involving a much longer period of time than human life. Such registers of the date of given depths of peat have been found in works of art, or in the marks of human industry which have been submerged in it, and of which the time admitted of being ascertained within certain limits. From these several modes of judging, it has appeared, that the time required for the formation of a given depth of this substance, is so various, that no general conclusion can be drawn on the subject. It has been remarked on the Continent of Europe, that cavities of seven feet in depth have been filled with it in the short space of thirty years. This occurrence is, however, limited to partial spots, and depends on a combination of favourable circumstances, which must be considered rare. It only takes place in the smaller excavations, in which the vegetation of aquatic and marsh plants is unusually luxuriant. Two cases have often been quoted, of peat-mosses formed on fallen forests, the one at Drumlanrig, the other near Loch Broom, the former of which was completed in sixty, the latter in fifty years; but as the depth is not specified, no conclusion can be drawn from these instances. In innumerable other instances, Roman works of art, and traces of Roman roads, have been found beneath peat-mosses, but the depth has seldom been measured; so that from these also, no conclusion respecting the quantity produced in a given time, can be drawn.

In a few cases, however, the depth has been measured. A coin of the Emperor Gordian, is quoted as having been discovered at thirty feet in depth; and other Roman coins are mentioned as having been found in Italy even at that of fifty feet. From the latter, of which the dates are not given, the time required for the production of this quantity of peat, can only be conjectured within very wide limits. In this country, Roman utensils, and traces of Roman roads, have been found at the depth of eight feet; but as other parts of the moss in the spot in question attain to the depth of twenty feet and upwards, the quantity produced within the time ascertained by this register, may be considerably greater. Recently, the palings of a park described by Camden, have been discovered beneath Chat Moss; but the depth of superincumbent peat in this place has not been mentioned.

It appears unnecessary to be anxious on this subject, as, from a variety of circumstances, it must appear evident that no general conclusions can be drawn. The chief causes which influence the growth of peat, are situation, temperature, and the degree of moisture, all of them being causes which affect the rapidity of vegetation. In those cases where mountain-peat is in contact with the solid rock, it is obvious, that its growth, particularly in the first stage, must be very slow, as the time which the lichens and mosses require to lay the foundation of a vegetating surface is considerable. In all cases, the peat of drained declivities is of tedious growth, and, as was formerly mentioned, rarely attains a greater depth than two feet. The production of marsh and of lake peat, are on the contrary rapid, and that in proportion to the circumstances of various kinds, by which the luxuriance of vegetation in these situations is promoted. That of forest-peat must, in most cases, be even more considerable, as a sudden accession of depth is produced by the fall of the trees which contribute to its formation. Many of the deeper mosses of all countries, appear accordingly to owe a large portion of their bulk to this cause, and are found in places well known by historical record, as well as by internal evidence, to have been once occupied by forests.

Where no registers of time, derived from submerged works of art, or from historical record, can be discovered, the antiquity of any given mass of peat may be presumed from other circumstances. These are, chiefly, its alternation with beds of clay or alluvium, and the degree in which it approximates in its chemical qualities to brown coal or bituminized wood. The latter change requires a length of time greater than that during which the greater number of the superficial peat-mosses of this country has existed; and, in most cases, the alluvia which have been generated by the deposits of rivers are evidently of a very high antiquity.

Under the various circumstances in which peat is found, it exists, as a soil, in various states, namely, in that of a fibrous and spungy mass, a powdery substance, a compact body, and a semifluid paste. The former condition occurs in all cases where the process has not been perfected, and presents infinite varieties. The second state is peculiar to mountain or drained peat. Compact peat, again, forms the predominant variety, in Scotland at least, as far as the mere bulk of the deposit is concerned; although the drier kinds occupy a much wider extent of surface. The semifluid state occurs, not only in transported peat, but in other cases where it has been formed in lakes or marshes, which, from their forms, have the power of retaining water. Time consolidates even this peat, by filling the cavity with solid matter, and thus gradually excluding the water; but it may continue for a long period in that state, as it does peculiarly on the continent of Europe. The well known inundations of fluid peat, have arisen in these particular cases, from the failure of the barrier by which such a cavity was bounded.

It is not within the limits of this paper, to notice the capacity of these several kinds of peat for receiving agricultural improvement, nor the various well known methods by which they may be brought into cultivation. It must, however, be obvious, that no general rules can be applicable to the whole, and that the great diversity of qualities possessed by this substance, indicates corresponding differences of treatment. It is also evident, from watching the natural processes by which peat is converted into soil, that pulverization forms the essential part of every mode of treatment. In draining a compact peat, art thus imitates what nature effects on mountain declivities; and, in mixing earths with it, the same results follow, which, in nature, occur from the dispersion of sand in the neighbourhood of the sea, from the intermixture of clay and sand near the estuaries of rivers, and from other more tedious actions by which its texture is loosened, and maintained in a lax state. It is in these cases that peat becomes naturally susceptible of cultivation with comparative ease; and it is by attending to these circumstances, that the agriculturist must be directed in the choice of subjects for his improvement, wherever a choice is in his power. A consideration of the effects produced by the application of calcareous manures, by burning, and by other means, must be left to those under whose peculiar province this subject falls.

The brown colour of mountain-streams evinces the partial solubility of peat in cold water, or at least proves that the mass in question contains a soluble ingredient. The quantity of matter thus held in solution is however small, and seems only to be extracted during the incipient or incomplete stages of the process. Peat, of which the formation is perfected, appears to communicate no stain to cold water, although boiling water still extracts a portion of the same ingredients. Water thus impregnated has been supposed to possess some peculiar antiseptic powers, the existence of which is, at best, doubtful, and which, if they do exist, appear to depend on accidental impregnations, not on the peculiar hydro-carbonaceous compound which communicates the brown colour. The obscurities which have attended this subject, appear to have arisen from inattention to the various nature of the substances which may be, and occasionally are, dissolved by waters flowing over peat, or stagnating in its cavities. One of these must be considered of an accidental nature, and it is the tanning principle extracted from the undecomposed bark and roots of various vegetables, and, among others, from the Tormentilla erecta. It is probable that, where animal bodies have been preserved in a state of integrity in peat water, this tanning process has been the cause; although, in certain cases, the constant application of mere water is capable of preventing the putrefaction of the muscular and membranous parts of animals, by converting them into adipocire. Peculiar effects are also produced by ferruginous solutions, which must also be considered as accidental, and which appear to arise from the conversion of pyrites into sulphate of iron. It is not improbable that, where tan is held in solution, a portion of gallic acid may also occasionally be dissolved; but it is nearly impossible to put these subjects to the test of direct experiment, from the difficulty of procuring solutions of peat in a state fit for such accurate examination. The acid which may be extracted from peat, by decoction in water, is small in quantity, and appears rather to be generated by the same process which converts the vegetable fibre into peat. It will hereafter be seen, that when vegetable matter is exposed to heat, the carbon and hydrogen enter, together with portions of the other vegetable elements, into new compounds, some of which are partially soluble in water. A familiar instance of this occurs in the roasting of coffee. During this process a portion of acid is also generated, which, on pushing the process to extremity, forms a conspicuous part of the result of the destructive distillation of vegetable matter. The action of water on vegetables, in the case of peat, as in that of manure, produces hydro-carbonaceous compounds of an analogous nature, some of which are similarly soluble in water, while others form insoluble peat; and it appears a necessary consequence that, in this process also, acetic acid should be generated. The acid extracted from peat is in fact acetic acid, but the time required to conduct a direct experiment of this nature, so as to produce a decided result, is such as to prevent the possibility of instituting any for that purpose.

The soluble hydro-carbonaceous compound which communicates the brown colour to peat water, resembles, when obtained in a state of purity, that which is generated by the decomposition of manure, (abstracting the salts which abound in this,) as well as that which is produced by roasting coffee, or by the application of a regulated heat to other vegetable matters. It is like that also which, in highly torrified malt, or in sugar, communicates the brown colour to malt liquors. It is probable that, in all these cases, this compound is subject to considerable variations; but chemistry as yet offers no certain methods of accurately distinguishing these. Distillation, which separates the hydrogen and other volatile matters from the carbon, proves differences, the exact degree of which it does not enable us easily to appreciate.

This compound, as it is deposited naturally from peat waters, is sometimes found in bogs in such quantity as to admit of ready examination. Occasionally, it is dispersed among the more solid peat, which consists of powdered materials, fragments and fibres, to which it communicates a black colour and pitchy appearance. It cannot then be extracted by water, as far as I have experienced, since, when once hardened, and in a detached state, it is not soluble even in boiling water. When first this matter is procured, it is soft, but when dried, it is brittle, and breaks with a splintery and conchoidal fracture, presenting a considerable resemblance to asphaltum. It also sometimes resembles that substance in lustre, but is at other times dull, and the colour is black. It is heavier than water, and is not electric. It is not acted on, as already remarked, by boiling water, nor is it soluble in alcohol, ether, or naphtha; in which latter circumstance its difference from asphaltum, which it otherwise so much resembles, is strongly marked. On distillation, it gives the same results as ordinary peat, namely, acetic acid and vegetable tar, the charcoal remaining behind. These results prove, that, like undecomposed vegetables and peat, it contains oxygen as well as hydrogen and carbon. The quantity procured for the experiments in question, was too small to show whether any azote exists together with the other elements, as no ammonia was found in the small proportion of acid obtained.

It has not, as far as I know, been observed by our numerous writers on this subject, that peat is occasionally luminous, although a remark of an analogous nature is made by some oriental traveller, whose name does not at this moment occur. I have often, however, witnessed this appearance, and most remarkably in the bared bogs of North and South Uist. The luminous matter is dispersed in small points over the brown surface, and as these are very minute, while the colour of the light is also blue, they are scarcely visible at a small distance, whence, probably, they have escaped notice. This fact is analogous to that which occurs during the decomposition of wood; but the present state of chemical analysis does not appear to offer any means of ascertaining the cause of the phosphorescence.

The specific gravity of peat varies considerably, and, in a great measure, in proportion to the degree of its perfection; in a few instances it is found to sink in water. Its qualities as a fuel depend much on its varying condition in this respect; that of North and South Uist, and of this chain of islands in general, is so compact as to afford a flaming fuel nearly equal to the inferior kinds of coal, while, after being once dried, it is again incapable of absorbing water.

(To be concluded in our next.)

ART. IX.—*Account of a Peculiar Modification of Vision.* By JOHN GILLIES, M. D. Member of the Wernerian Society. In a Letter to Dr Brewster.

DEAR SIR,

IN compliance with your request, I now send you an account of the singular modification of vision formerly mentioned to you, and of which I can find no similar instance on record. It occurred frequently to me during the year 1816. Since the third day of the following year, with but three exceptions, and these at very distant intervals, I have never again experienced any return of it. I have to regret much, that my observations on this subject have been rather limited and imperfect. On this account I have purposely deferred laying the particulars before the public, in the expectation that their recurrence might enable me to render them more complete; but of this there is now very little probability, when so long a period has elapsed since this affection has visited my eyes with any degree of frequency.

This modification of vision usually made its appearance in the following manner, without any previous intimation of its approach. When sitting in company, or otherwise engaged in any occupation not requiring continued or minute attention, all objects within the range of my vision, appeared to recede from me, and be proportionally diminished in magnitude. These appearances at first were generally so very slightly different from my natural vision, as to produce in my mind some doubt whether I had not been deceived in supposing there was any difference. Any doubt of this kind, was, however, soon removed by a gradual increase from one degree to another, till it had reached its maximum, which usually took place in the course of a few minutes from the commencement. In this condition, which on different occasions varied considerably in point of intensity, my vision continued for a longer or shorter length of time, and then the affection disappeared in the same gradual manner as on its accession, till at length it became so very slight as to be with difficulty distinguished from my natural vision.

Such was the ordinary succession of phenomena, as they occurred in my vision, on those occasions to which I have alluded. There are, however, several other circumstances which require to be mentioned more in detail: These, for the sake of brevity and arrangement, I shall state under separate heads.

The *duration* of this affection varied considerably, from a few minutes to seven or eight hours; in ordinary cases, however, it only continued from half an hour to an hour. In frequency of recurrence it varied also exceedingly. During the summer of 1816, when these phenomena first made their appearance, it usually came on about once every two or three weeks, but these attacks became much less frequent during the succeeding autumnal months. However, in the months of November, December, and the early part of January 1817, they became much more frequent and troublesome, recurring every eight or ten days; sometimes appearing daily for several days in succession. It appeared to have reached its maximum degree of frequency about the commencement of the year 1817; for, during the 31st December, the 1st, 2d, and 3d of January, it came on in such rapid succession, that I seldom enjoyed my natural vision longer than two or three hours at a time, often indeed only for a few minutes; but I may here observe, that although its recurrence was so very frequent, yet it seemed gradually to diminish in duration each time.

In *degree*, this affection likewise varied very much, and occurred in every variety from the slightest deviation from the natural vision to its most intense degree, which I find much difficulty in estimating with tolerable precision, as I had no standard to judge by, or any other guide, except my own sensations; but, from the observations I was enabled to make, I am inclined to think, that on some occasions the surrounding objects appeared to my eye as if removed to *six* or *eight* times their real distance. These sensations were neither confined to objects near me, nor to those at a distance, but were equally participated in by every object within the range of my vision. Thus, I have observed a row of lamps of about three quarters of a mile in length, to bear the same proportional relation to my eyes as during my natural vision; while, on the other hand, when seated in an apartment, and under the influence of this affection, had I trusted solely to my sensations of vision for information, I should have been induced to think, that objects which I knew I could touch with my hand without rising from my seat, were removed several feet farther from me, and altogether beyond the reach of my fingers if I extended my arm.

During the latter part of the 31st December 1816, when this affection seemed to have reached its greatest degree of intensity, on which occasion it continued with scarcely any intermission upwards of eight hours, these sensations were experienced in every variety of degree, from the slightest to the most intense form which I had ever experienced, and these often varying and alternating with each other.

Being very desirous to determine whether, during the continuance of this affection, the apparent diminution in the magnitude and increase in the distance of surrounding objects, bore the same relative proportion to each other which they did during my natural vision, I endeavoured to make some observations on this point; but from the want of any good rule by which to estimate, and the fallacy to which all observations, resting solely on individual sensation, are liable, these have been very unsatisfactory, and I cannot speak with any certainty on the subject; yet there is an impression on my mind, that they were exactly proportioned to each other.

In general, I remarked that the distinctness of surrounding objects did not seem to be impaired in a greater degree, than if they had been actually removed to the same distance at which they appeared to be.

I have never been able to assign any probable cause for the occurrence of this affection of my vision; but it may be worthy of remark, that it never came on while I was engaged in reading or writing, or in any other occupation which required steady, continued, or minute attention, but most commonly attacked me when I was in company, or while engaged in conversation with any one, and when my eyes were employed viewing surrounding objects, without their being stedfastly or exclusively directed to any one of them.

Having remarked those circumstances under which I seemed to be exempt from these accessions, it occurred to me, that the employment of similar means might prove effectual in accomplishing its removal, when it had already made its appearance. Accordingly, at different times, while under the influence of this affection, I tried the effects of reading, writing, and the employment of magnifying glasses of different degrees of power. All of these seemed, on some occasions, to remove the affection, while at other times they failed in doing so; which induces me to think that, on the former of these occasions, my eyes were of themselves about to resume their natural condition, and were little influenced by these external agencies.

On reading, when I held the book at the usual distance from my eyes, I saw the words as distinctly as usual, though they appeared smaller and more distant than ordinary; but the exertion used in reading on such occasions, generally soon brought on such uneasiness of the eye, as to oblige me to desist.

The magnifying glasses, which I employed of various degrees of power, produced no other alteration in my sensations of vision than I should have expected of them, had the objects viewed been actually at the same distance, and of the same magnitude as they appeared to be to my vision at the time. No alteration was produced in my eyes, while in this state, from bathing them in cold water, and rolling them about in it for some time.

To determine whether these peculiar sensations were confined to one of my eyes, or extended to both of them in common, I alternately covered one eye and used the other, and uniformly found that the appearance of surrounding objects was precisely the same as when both eyes were uncovered.

At one time I supposed that this modification of vision might be somewhat connected with an increased fulness and determination of blood to the eyes, and frequently imagined I felt them more tense and uneasy during the time of its continuance, and after it had disappeared, than at other times; but after making repeated observations on the subject, I was induced to relinquish my first opinion, since I did not remark any unusual sense of fulness in those cases where I had used but little exertion of my eyes, which inclined me to ascribe these uneasy sensations to my having overstrained them, and to paying more particular attention to my sensations at the time than on other occasions. In general, indeed, I suffered little inconvenience from it, with the exception of its unfitting me, during its continuance, for any serious occupation, where my vision was required.

While under the influence of this affection, my eyes were repeatedly examined by various professional gentlemen, none of whom could perceive the slightest deviation from the natural appearance of these organs, or any apparent alteration in the convexity of the cornea. Among these I may be allowed to mention the names of Dr Farre of London, and of my much respected friend and preceptor, the late Dr Gordon, whose merits as an acute and intelligent physiologist and anatomist, as well as his private worth, will long endear his memory to every one who had the advantage of knowing him, or of listening to his instructions.

These remarks constitute the very limited and imperfect observations which I have been able to make on these occasions. Such as they are they may be relied upon, being the result of actual observation; and with some, perhaps, will be considered the more worthy of attention, as I have no particular theory to support,—a source of fallacy which cannot be too much guarded against, in making observations on one's own sensations.

As I have been unable to bring forward any satisfactory explanation of these phenomena, I have altogether refrained from giving any opinion on the subject, but presume that it may be dependent on some modification of the adapting power of the eye to near and to distant objects.

These observations, however, seem to lead to the following conclusions:

1*st*, That this modification of vision always made its appearance in a gradual manner, proceeding progressively, and almost imperceptibly, from one degree to another, till it had reached its maximum; and constantly disappeared in the same gradual and progressive manner, but in a reversed order.

2*d*, There was no apparent diminution in the distinctness or clearness of surrounding objects, further than might have been expected from their actual removal to their apparent distance.

3d, That external agents exerted no influence in producing or removing this state of the vision, which seemed to be wholly dependant on causes situated in the eye itself. The circumstance of its never having appeared while employed in some particular occupations, may have been purely accidental, from my never having been so engaged while there was a disposition in the eye to assume this state.

Any further remarks I leave to those more conversant than myself with the science of optics, and should be happy to hear their opinions on the subject, and will with pleasure attend to the suggestion of any of your readers, should any method occur to them whereby I might vary and extend these observations, in the event of my being again affected with this modification of vision. I am, &c.

2. HAY STREET,
25th October 1819.

JOHN GILLIES.

ART. X.—*Description of a new Atmometer,* invented by ADAM ANDERSON, Esq. A. M. Rector of the Academy, Perth *.

THE *Atmometer,* or, as it is sometimes called, the *Evaporometer,* for measuring the quantity of water evaporated in any given time, is an instrument which has not till lately been brought to any great degree of perfection. A circular basin, of uniform width from top to bottom, filled with water, is the simplest form of the instrument, and the quantity evaporated may be very accurately ascertained by means of a graduated glass tube, similar to that employed for measuring the depth of rain. There are several difficulties, however, attending the use of the instrument, which render it a very uncertain indication of the absolute quantity evaporated. If it be exposed freely to the sun and wind, the heat acquired by the vessel itself will rapidly promote evaporation; and if the basin be kept nearly full, as it ought to be, the water will be agitated and thrown over by the wind. Nor do we conceive, even though this last accident were guarded against, that the result would be either satisfactory or important. If the object of the atmometer be to ascertain the dissolving power of the air, it may be accomplished by placing the basin in a sheltered situation, as well as if it were freely exposed; and if the quantity evaporated from the ground be required, the simplest and the most accurate method is that adopted by Mr Dalton.

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* The following account of this beautiful instrument is copied, by permission, from the MS. of the article *Meteorology,* drawn up for the Edinburgh Encyclopædia.

An atmometer, upon a very simple principle, was some years ago constructed by Mr Leslie. It consists of a ball of porous earthen-ware, two or three inches in diameter, into which is inserted a glass tube, so graduated, that the quantity of water contained between two divisions of the tube, would cover the outer surface of the ball to the depth of one thousandth part of an inch. The ball and tube being filled with water, the top of the latter is covered with a brass cap, which, by means of a screw and collar of leather, is made quite air tight, and the instrument is suspended out of doors, freely exposed to the wind. In this state the humidity exudes through the surface of the ball, just as fast as it evaporates, and the descent of the column in the tube indicates the quantity evaporated. As the pressure of the atmosphere is in a great measure removed by the tightness of the collar, the water is prevented from passing through the ball so quickly as to drop, while the space which it leaves empty at the top, is occupied by the very minute stream of air which is imbibed by the moisture on the outside, and may be seen rising through the water in the tube.

This instrument, as we have found from numerous trials, is totally useless for a continued series of observations. The obvious impossibility of using it in frosty weather, is itself an insuperable objection, but there is another which renders it equally unsatisfactory at all seasons of the year. Though a portion of air, as we have already remarked, is imbibed by the humid surface of the ball, and rises into the part of the tube from which the water has subsided, it is in so small a quantity as to exert very little pressure on the surface of the water: The consequence is, that during a shower, the rain that falls on the surface of the ball is forced into the interior, so that the water again rises in the tube; and though the elasticity of the air above must at length counteract this process, it is still sufficient to render the indications of the instrument altogether uncertain. As a proof of this, we shall mention one instance among several others that might be stated. On an evening of a dry summer day the water in the tube of the atmometer stood at 100; during the night there was a heavy fall of rain, and next morning the surface of the liquid was as high as 15. This fact we apprehend is decisive as to the merits of the instrument. It is therefore totally unfit for measuring the quantity of evaporation during an interval of any considerable length.

The atmometer recently invented by Mr Anderson, is undoubtedly the simplest as well as the most ingenious instrument of the kind hitherto proposed. It consists of a bent glass tube ABCDEF (Plate I. Fig. 5.), of sufficient width to admit of a liquid moving easily from one part to another, and swelling out into the bulbs BC and EF. Into this tube at A is introduced a quantity of alcohol, which, after being conveyed into the bulb or wider tube EF, is thrown into a state of ebullition, and while the steam is issuing from A, the tube is there hermetically sealed, so that the air is completely expelled from the space ABCDE. The bulb BC is then covered with moistened silk or paper, and the instrument freely exposed. In consequence of the pressure of the air being removed from the surface of the alcohol in the bulb EF, a portion of that liquid passes into vapour, and occupies the empty part of the tube. Were the whole of the instrument at the same temperature, this process indeed would quickly be stopped by the pressure of the vapour itself on the surface of the alcohol; but as the bulb BC has its temperature reduced by the external evaporation from the moistened silk or paper, the vapour which rises from EF is there condensed, and runs down in a liquid state into the tube AB. This distillation goes on more or less rapidly, according to the degree of cold induced upon the bulb BC, that is, in proportion to the external evaporation; and, consequently, the quantity of liquid collected in the tube AB, is a measure of that evaporation. When the atmosphere is completely saturated with moisture, or when the evaporation ceases, the temperature of AB will be the same as that of any other part of the tube, and the distillation, therefore, for the reason already stated, will also cease.

The measure of evaporation thus found, is expressed in inches and decimals of an inch, by means of an attached scale GH, the divisions of which are determined by experiment. Suppose, for example, that the instrument is exposed to similar circumstances with an evaporating basin, and that the quantity evaporated from the latter in a given time, as determined either by weight or measurement, is found to be one-tenth of an inch, while the alcohol distilled by the former in the same time, fills the tube AB to the depth of one inch, then the scale being divided into inches and tenths, will indicate tenths and hundredths of an inch of evaporation. By increasing the proportion between the diameters of EF and AB, the quantity of evaporation may be measured to any degree of minuteness required. In using the instrument, the tube EF is to be sheltered from rain by inclosing it in a case or cover, to prevent its temperature being reduced below that of the atmosphere by subsequent evaporation; and the bulb BC is to be kept constantly moist by means of a small cup containing water attached to the tube immediately below it, the silk or paper being in contact with the water, or from an adjoining vessel, as in the case of the hygrometer. The instrument is placed in a vertical position, and is prepared for a new observation by inverting it, so that the distilled alcohol may be conveyed back to the tube EF. It is to be hoped, that this beautiful and ingenious contrivance will soon meet with that reception among meteorologists, to which its merits so well entitle it. This atmometer has already been constructed, and is found to possess the utmost delicacy. It is probable that it may in time supersede the use even of the hygrometer.

Art. XI.—*Sketch of the Distribution of Rocks in Shetland.* By Samuel Hibbert, M. D. M. W. S. &c. (Continued from Vol. I. p. 314.)

In the former part of my paper, I commenced with describing the more southerly strata of Shetland, situated at Fitful Head, which were found to consist principally of clay-slate, with the addition of gneiss and mica-slate. Tracing them from the south, the whole were observed to be intercepted in their course by a mass of epidotic sienite, extending from Quendal Bay to Spiggie. In the next place, I described the sandstone or granular quartz extending from Sumburgh Head to the Islands of Mousa, Bressay and Noss, distinguished by containing no apparent fragments of other rocks, as of granite, quartz and felspar; whilst to the west of it was a conglomerate sandstone, in which such portions were disseminated. This conglomerate sandstone was associated with another rock, consisting altogether of portions of other masses, as of granite, quartz, felspar, and occasionally of gneiss. The whole of these conglomerate strata were shown to rest, by their inferior edges *, upon the surface formed by the superior edges of a variety of strata, as of quartz, mica-slata, gneiss, limestone, &c. Lastly, were described the strata of the Cliff Hills, lying to the west of the conglomerate rocks and sandstone, consisting of clay-slate, whilst again, to the west of the clay-slate, were certain associated strata of quartz and hornblende-slate. All these strata were shewn to be in contact with the northerly bounding side of the epidotic sienite, which they met at an angle, or, in other words, by an attachment of their lateral edges. Again, the associated strata of quartz and hornblende-slate were found for a considerable distance to run nearly parallel to the strata of clay-slate, until, to the north of Scalloway, they began to be inflected to the eastward, so as to intercept, at Dale's Ness, the whole of the strata of clay-slate. But certain other strata of quartz and hornblende-slate, appearing to the east at Dale's Voe, and again, still more easterly at Rovie Head, occurring certain associated strata of quartz and limestone, these additional masses were represented in the character of nuclei, as affording attachments to new strata of clay-slate, which, in a more easterly direction, maintained a course from one apparent nucleus to another.

I shall now continue my description of the rocks in Shetland, in reference to the map annexed to this number, which is intended to represent a horizontal section of the country. Certain strata of limestone, will therefore be first noticed, situated to the west of those associated strata of quartz and hornblende which we had traced from Dunrossness.

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* For the reasons which induced me to adopt such new terms as *superior*, *inferior* and *lateral* edges of strata, I beg leave to refer to the first part of my paper, which appeared in Number II. of this Journal.

STRATA CONNECTED WITH THE LIMESTONE OF TINGWALL AND CATFIRTH VOE.

Here it is necessary previously to describe the mass of Limestone, since I consider it in the light of a nucleus, as affording attachments to the lateral edges of certain strata of Mica-slate and Gneiss, appearing at the same time to determine the extent and direction of their course.

The Limestone of Tingwall and Catfirth Voe.—East of the islands of House and Trondra, first appears, as we trace it from the south, an important mass of limestone, occasionally associated with hornblende-slate.

The form of the limestone, as represented in a horizontal section, is that of an elongated main trunk or body tapering to a point, from which are given off two easterly ramifications. The main trunk or body of the limestone may be traced in a direction of N. 5° E. (which is at the same time nearly the direction of the strata) from House Island to the Vale of Tingwall, and thence to the north of Catfirth Voe; its length being about thirteen miles, and its greatest breadth about 1200 feet. The first easterly ramification which we observe, and which is denoted by a corresponding change in the direction of the strata, passes through the Channel of Laxfirth Voe to Glitness. The second ramification passes through Vassa Voe, and the small isthmus of Brough, where, like the first, it becomes lost by the approach of the sea.

The Mica-slate in the Peninsular Tract of Eswick and Glitness, south-east of Vassa Voe.—The mica-slate thus geographically described, may be also traced from the Mainland to the distant rocks named Grief Skerry, Rumble Island, Linga, and Isbaster. These strata afford an example in their junction with the limestone, of a circumstance of relative position which I formerly described. Here the lateral edges of the strata of mica-slate are so opposed to the lateral planes of the strata of limestone, as to be intercepted by them. The general course of the strata of mica-slate, is from the main trunk or body of the limestone (if I may so name it), also from the southerly ramification of the limestone which passes through Laxfirth Voe and Glitness, to that northerly ramification, described as passing through Vassa Voe and Brough, by which it is intercepted.

The direction of the mica-slate is very various, being from N. 25° E. to even N. 60° E., increasing in this respect as we pursue an easterly course, calculated to cross the strata. The dip is to the west, generally at angles of about 45°.

The Gneiss of Neap, Lunning-head, Whalsey, and the Outskerries.—Tracing these strata in a general direction from S. W. to N. E. we find them, near the head of Catfirth Voe, taking their course as well from the main trunk of the limestone, as from that northerly ramification which passes through Vassa Voe; consequently the circumstance of junction under which the gneiss is found, is similar to that of the mica-slate last described. Near this junction occur also small associated masses of granite, which seem to aid the limestone in affording attachments to the strata of gneiss.

Certain of the strata seem to be continued uninterruptedly in a north-easterly direction, through Neap to Whalsey and the Outskerries; whilst at Lax Voe a mass of sienite, about two miles in length, and half a mile in breadth, is opposed to the rest of the strata nearly at right angles. Their course being, however, resumed from other points of the sienite, the gneiss is variously continued to Lunning Head, to the islands between Lunning Head and Whalsey, to the western coasts of Whalsey and the Outskerries, and to Meikle Skerry.

These strata are much traversed by veins of granite, and occasionally by sienite. At the Outskerries occurs a small roundish mass of sienite on the Wart Hill, probably 300 feet in diameter, and a considerable bed of limestone, about 400 feet wide, the course of which is visible in a direction of N. 50° E. for a mile and a half.

The strata, taking their course from the limestone, granite and sienite, to which they are attached, are severally directed to different points of the compass, viz. from N. 35° E., by which direction they are probably continuous with the distant island of Meikle Skerry, to N. 50° E., by which they meet the limestone or sienite of the Outskerries. The dip is to the west, at a variety of angles. The strata are, however, much confused by the occurrence of innumerable small insulated masses of granite, seldom exceeding two or three feet in width. These subordinate masses afford complete epitomes of the different circumstances under which occur those mountain-masses of an independent form, which, in relation to the strata attached to them, I have conceived of in the light of nuclei, since they assume every variety of position and form, and meet strata at all possible angles. Thus I consider, that a study of the conditions of junction, under which small insulated masses of granite, sienite, porphyry, limestone or hornblende, are found with the strata which they traverse, will afford the most direct examples of the distribution of rocks of a similar kind, when, from their greater magnitude, we may consider them in the light of mountain masses. The rocks which disturb the course of strata, appear in fact, independently of magnitude, to differ from each other in two respects only. Certain strata attached by their lateral edges to rocks which I have regarded under the character of nuclei, may, in the first place, be observed to terminate altogether at the place of junction. From no other remaining points of the mass is a resumption of such strata to be found. On the contrary, either a new series or system of rocks, or strata of a similar kind, arranged in a totally different order, or perhaps with a direction and inclination equally varying, derive their origin from the remaining and generally opposite points of the nucleus. Secondly, Certain strata attached to a rock by their lateral edges, are not altogether terminated or intercepted, but only by such an occurrence *interrupted* in their course. We find that, from other points of the interrupting mass, similar strata are resumed, but frequently with some disturbance in their line of direction or dip. Under this view, every small insulated mass or vein which traverses strata, is a nucleus of a subordinate kind, which interrupts and disturbs, but does not eventually terminate the course of strata.

THE STRATA OF LUNNA NESS.

Lunna Ness is a considerable headland, constituting the north-easterly extremity of the Mainland of Shetland.

These strata consist of gneiss, appearing, from their proximity to the rocks of the same name last described, to form a part of them. The strata, however, of Lunna Ness are a distinct system. They exhibit certain imperfect manifestations of a conglomerated structure, by containing angular portions of quartz, which, however, most frequently graduate into the substance of the containing rock. The strata are traversed by numerous insulated veins of granite, and occasionally by those of sienite.

Two or three miles to the south of Lunna, at the head of Lax Voe, may be noticed a small mass of sienite, together with associated strata of quartz and limestone. These rocks, like nuclei, afford attachments to the strata of Lunna Ness; and accordingly we find, that in tracing the strata in a northerly direction from this, the most southerly point in which they occur, their course is continued in a direction of N. 12° or 15° E. to the extremity of Lunna Ness. Here the sea precludes a knowledge of the rocks by which they are intercepted to the north; but it is probable that the strata of Lunna Ness may be identified with gneiss of a similar conglomerated structure, occurring in the island of Hascosea, or with the strata of Fetlar, which are intercepted by the serpentine of that island.

The dip of the gneiss is to the west at various angles.

A little more than a mile to the north of the mansion at Lunna, are two or three remarkable detached rocks, named the Stones of Stephis. Of these the largest is about twenty-three feet in height, and ninety-six feet in circumference. No objects of geological notice have excited greater attention than fragments of this nature, regarding the origin of which, scarcely any opinion can be offered more than amounts to mere surmise.

In the present instance, it is to be conjectured, 1st, That these enormous detached masses cannot have undergone any very distant removal, since they repose on rocks of precisely a similar kind. Nor, in the 2d place, does it appear, that they have been loosened from rocks of a greater altitude, since they themselves occupy the most commanding site in their immediate vicinity. In the 3d place, If we are inclined to consider them as the detached remains of a pre-existing rock, being the only parts which have escaped a decomposition by which the rest of the rock had been removed, still we must admit that such a disintegrating process must, to any perceptible extent, have long since ceased; since, of all rocks in Shetland, the stones in question, from the quantity of quartz, and the little felspar which they contain, are the least prone to decomposition. That such a detached state is, therefore, an original condition of the rock, I shall consider as the most rational conjecture, until such reasons, as are the result of a more advanced state of geological science, can be brought forward to prove the contrary. At present, I am far from being convinced, that a state of cohesion must have been essential to the primary condition of rocks, or to the particles which make up their ingredients. The contrary, indeed, is rendered more probable, by appearances observable in other parts of the world, which are with equal difficulty attributable to the decomposition of pre-existing rocks, or to debacles.

STRATA CONNECTED WITH THE SIENITIC AND LIMESTONE MASSES OF THE CENTRAL DISTRICTS OF SHETLAND.

The examination of the central districts of Shetland, chiefly comprised in the Mainland and the islands in the Bay of Scalloway, will afford additional reason for regarding certain rocks in the light of nuclei, as affording attachments to the lateral edges of strata, and determining the extent and direction of their course. The rocks which are principally concerned in the distribution of the strata now to be described, are four in number. The first is a mass of epidotic sienite, which may be designated, from its situation, as the south-westerly mass of epidotic sienite; the second is a mass of limestone extending from Weesdale Voe to Dale's Voe in the parish of Delting; the third is a mass of sienite occurring in the vicinity of Olnasfirth Voe; and the fourth is a considerable mass of sienite, chiefly occurring in Hagrasetter Voe and Yell Sound.

Now, since the order in which I notice the strata is, as they are crossed from east to west, their course being at the same time traced from their southerly to their northerly points of attachment to other rocks, the strata to be described will, in relation to the nuclei which appear to determine their course, distribute themselves in an order that may be easily followed. After, 1st, describing certain strata of St Ronan's and Colsay, the relations of which, from the advances of the sea, are very obscure, and which, on bare probability, are supposed to maintain a course from the south-westerly mass of epidotic sienite, I shall, 2dly, proceed to describe strata with less doubtful relations, as probably maintaining a course from the south-westerly mass of epidotic sienite, until they are observed to be intercepted very far north by the limestone of Weesdale Voe and Dale's Voe: 3dly, will be described strata, the relations of which are sufficiently evident; these maintain a course from the south-westerly mass of epidotic sienite, to the sienite of Olnasfirth Voe: and, 4thly, strata will be noticed, which maintain a course from the sienite of Olnasfirth Voe, to the sienite of Hagrasetter Voe and Yell Sound.

1. *Strata, the relations of which are obscure, but conjectured to maintain a course from the south-westerly mass of Epidotic Sienite, until they are intercepted by the Limestone of House Island and Trondra.*

Here I shall take the opportunity of first noticing the south-westerly mass of epidotic sienite; and, in the next place, the strata of St Ronan's and Colsay.

South-westerly mass of Epidotic Sienite.—This mass, from the length of its course, which is fifteen miles, far exceeding its breadth, which is never greater than a mile and a half, would be named by geologists a Dike. Being first observed near Coleness in the island of Burra, it may be traced in the numerous contiguous islands and rocks, bearing the names of Papa, Oxna, Cheneys, the Stags, Hildazoo, the Sandistura Rocks, and Foreholm: from thence to the Channel of Sand Voe, Bixeter Voe, and, lastly, to Aith Voe, in the parish of Aithsting. The rock contains much epidote, besides hornblende, and is occasionally porphyritic, forming, when polished, a beautiful ornamental stone.

Strata of St Ronan's and Colsay.—At St Ronan's, a small peninsula near Dunrossness to the west of the Cliff Hills, we cross a series of strata, consisting of mica-slate, and of a gneiss which, in the skerries to the west of St Ronan's, is porphyritic. The dip of the strata is to the west, at various angles, averaging 45°.

It may be stated, that the mass of epidotic sienite, represented by numerous islands in the bay of Scalloway, is probably continued through the channel of the ocean, so as to meet the sienite of a similar kind in Dunrossness. For if the lines in the annexed map, which represent the bounding sides of each mass of sienite, be produced in very nearly the customary direction in which we have traced them, they will be found to join, or to be continuous. The lines also would pass so near the south of Colsay and St Ronan's, that the strata would appear to derive their course from the epidotic sienite, until, as we may infer from the direction of the strata, they are intercepted by the limestone at House Island and Trondra to the west of the Cliff Hills.

2. *Strata supposed to maintain a course from the south-westerly mass of Epidotic Sienite, until they are intercepted by the Limestone extending from Weesdale Voe to Dale's Voe, in Yell Sound.*

After describing the mass of limestone which intercepts the strata to the north, we shall be better prepared to consider the relations of the strata both to the epidotic sienite and to the limestone.

Limestone continuous from Weesdale Voe to Yell Sound.—This mass of limestone, of an elongated form, eighteen miles long, and about twelve or fourteen hundred feet wide, first makes its appearance, as we trace it from the south, in the archipelago of islands near the mouth of Weesdale Voe. From thence it is continued in a direction of nearly N. 12° E. to the head of Weesdale Voe, and over a covered country as far north as the head of Olnasfirth Voe. Here the limestone assumes a new direction, being inflected considerably to the eastward; it thus continues in its new course to the east of Dale's Voe, in Yell Sound, disappearing at length in the peninsula of Foreholm.

In order to shew the mode by which the strata are intercepted by those of the limestone, I shall on this occasion consider them in an order the reverse of that which I have hitherto adopted. This is the order in which they would successively appear to us as we cross the strata from west to east, after leaving the limestone of Weesdale.

Strata of Beneness, and the hill named the Long Kame.—These strata are of mica-slate, approaching, however, by the slight presence of felspar, to the nature of gneiss. The rock is distinguished by the dark colour of its mica. These strata may, at the point of Beneness, and the islands of Havery and Longa, be observed in the immediate vicinity of the cluster of rocks and islands which denote the track of the epidotic sienite. At the island of Papa the junction is manifest. Thus there can be little doubt, but that the course of the strata is derived from the sienite. This course is maintained nearly as far north as the head of Olnasfirth Voe, in a direction almost parallel to the course of the limestone of Weesdale. But at Olnasfirth Voe, where the limestone begins to be inflected in its course to the eastward, the lateral edges of the strata of mica-slate, which do not deviate in their line of direction, begin to be successively opposed to the lateral planes of the strata of limestone, until a complete interception of the mica-slate is induced. The general direction of these strata is about N. 12° E.; the dip is to the west at angles from 45° to 70°.

The strata continuous from the Islands of Great and Little Havery, near Dunrossness, to the Islands of Yell Sound.—These strata are of gneiss, with the exception of a few to the east of them, which are of mica-slate, and they are traversed every where by insulated veins of granite, which often contain talc in the place of mica, and occasionally by hornblende and sienite. We trace this very considerable mass of gneiss from Great and Little Havery to the large islands of House and Burra, to the west of Trondra, to the Mainland west of Scalloway, where it forms a long chain of hills, named the Eastern Kame, extending to Swinnin Ness and Colafirth Ness, in Yell Sound, to the peninsula of Foreholm; and, lastly, to an island in Yell Sound, named Weatherholm.

At Coleness, in the Island of Burra, where the epidotic sienite, as we trace it from the south, is first manifested, the strata of gneiss appear in junction with it. But since the continuity of the epidotic sienite with the similar rock of Dunrossness, already described, cannot, from the inroads of the sea, be established, we can only speak to the great probability there is, that the strata of gneiss derive their course from the epidotic sienite. This course is uniformly continued in a stratified direction of N. 12° E., until the gneiss, a little north of the Head of Olnasfirth Voe, begins to be opposed to the limestone extending from Weesdale Voe to Dale's Voe. The interception of the mica-slate of the Long Kame having been accomplished, that of the strata of gneiss situated to the east of it follows: accordingly, the course of the greatest part of the strata is manifestly terminated in the peninsula of Foreholm, which is the most northerly point to which we can trace the limestone. It is highly probable, that in the channel of Yell Sound, the interception of the few remaining strata is completed.

A subordinate mass of limestone of a very pure quality, occurs in the island of Great Havery, whilst another, five miles long, and two to three hundred feet broad, may be traced from the bridge connecting the islands of House and Burra to Burwick on the Mainland. The strata dip to the west at a variety of angles, generally about 45°.

Limestone of Ustaness.—A mass of limestone, presenting in a horizontal section an elongated form, and tapering to a point, is interposed between the mica-slate of Beneness and the gneiss last described. It is eight miles long, and its greatest breadth exceeds sixteen hundred feet. The direction of the strata is nearly due north, varying some little from that of the strata on each side. That this interposed mass of limestone has the effect of intercepting strata, is shewn by a diminution of the breadth of the gneiss, to an extent corresponding to the space occupied by the limestone.

3. *Strata maintaining a course from the southerly Mass of Epidotic Sienite to the Sienite of Olnasfirth Voe.*

Here a proper occasion is afforded for describing the sienite of Olnasfirth Voe: we shall then have two unstratified masses made known to us, which, like nuclei, appear to determine the course of connecting strata.

Sienite of Olnasfirth Voe.—That part of the mass which occupies the bed of Olnasfirth Voe, is distinguished by its dark colour, and by containing very little mica. But to the north and north-west of Olnasfirth Voe, another rock of sienite is annexed to it, which is characterised by the quantity of epidote which it contains. In this additional mass of epidotic sienite, there is much less hornblende and more felspar, than in those rocks of the same name which I have before described. The magnitude of the rocks taken collectively, may be estimated at five miles in length, and one mile in breadth.

Mica-Slate of Weesdale Hill.—This rock is distinguished by the light colour of its mica; it also contains some trifling quantity of felspar. The strata most unequivocally maintain a course from the epidotic sienite in the Bay of Scalloway to the sienite of Olnasfirth. In their course they form a chain of hills, which, with the exception of Ronas Hill in North Mavine, are the highest in Shetland. The elevation of the hill at Weesdale is estimated at about 1200 feet; Scallowfield, a more northerly eminence, is somewhat higher, and there is a very considerable hill bounding Olnasfirth Voe. The direction of these strata is about N. 12° E., like that of the other rocks described. The dip is generally to the west, at angles very nearly vertical.

Gneiss extending from Foraness and Rusaness to Grobusness in Olnasfirth Voe.—The gneiss thus described, which is much traversed by insulated veins of granite, has a direction of N. 12° E., dipping to the west at angles of about 45°. The course of the strata is from the epidotic sienite of Sand Voe and Bigsetter Voe to the sienite of Olnasfirth Voe. In the gneiss of Selaness in Aithvoe, may be observed the vein of granite to which I formerly alluded in speaking of the conglomerate rocks. It contains rounded concretions six or eight inches in length, and these, if we were ignorant that they were taken from a rock exhibiting in no other instance appearances of a mechanical origin, would be readily conceived of as water-worn pebbles. The vein is six feet in width.

At the Burn of Taitagill, where the gneiss and the Weesdale mica-slate pass into each other, an extraordinary quantity of porcelain earth is accumulated, by the decomposition of the felspar which the gneiss contains. No experiments have yet been made to ascertain if the substance is applicable to the arts: it is thus found on the estate of John Ross, Esq. of Weesdale.

4. *Strata maintaining a course from the Sienite of Olnasfirth Voe to the Sienite of Hagrasetter Voe and Yell Sound.*

Our notice of these strata, previously leads us to that of the most northerly mass of sienite remaining to be described.

The Sienite of Hagrasetter Voe and Yell Sound. This mass of sienite presents, in a horizontal section, somewhat of a pyriform appearance, the outline of which may be traced by commencing our investigation from the grounds of Thomas Gifford, Esq., close to whose mansion the rock first appears. The boundary line may then be traced north, along the western banks of Hagrasetter Voe, the western side of the peninsula of Glus, the extremity of Ollaberry Ness; then in a south-easterly direction in Yell Sound, through the islands contiguous to each other, named Brother Island, Little Rhoo, Biga, and Samphray; thence to Firth's Voe in the Mainland, and in a westerly direction to Girthness Voe. It is then continued in the bed of Hagrasetter Voe, re-appearing, however, in the isthmus dividing that channel from Busta Voe; and, lastly, we return to its southerly origin at the grounds near Busta. The sienite, as we thus trace it, is 33 miles in circumference. Its utmost length is 12, and its greatest breadth is 8 miles.

At Tofts Voe, and in the islands of Yell Sound, this mass of sienite has a conglomerated structure, containing large apparent angular fragments of hornblende, some also being so rounded, as to impress upon the mind, at first sight, the existence of water-worn pebbles. This notion will, however, receive little support from the frequent graduation of such apparent pebbles into the substance of the containing mass. A circumstance most meriting attention in our examination of this rock, is the occasional appearance of strata of gneiss in the very centre of the sienitic mass. Such strata are, however, of inconsiderable extent, seldom exceeding a quarter or half a mile in breadth. This manifestation of included strata of gneiss, is observable near Tofts Voe and Brough, on the shores of Yell Sound.

Gneiss and Mica-slate between Hagrasetter Voe and Dale's Voe.—These strata, bounded on the west by part of Hagrasetter Voe, and on the east by Dale's Voe, may be traced in the northerly direction from their attachments to the sienite of Olnasfirth Voe. They thus maintain a course from the sienite of Olnasfirth Voe, to the sienite of Hagrasetter Voe and Yell Sound.

The strata consist for the most part of gneiss, but to the east the felspar becomes evanescent, and we have rocks possessing more the character of mica-slate. The strata to the west have a direction of about N. 15° E.; but as we cross them from west to east, the direction varies accordingly, by being more easterly also. The dip is to the west, at angles from 45° to 70°.

I have at length concluded my account of the strata connected with the sienitic and limestone masses of the central districts of Shetland, with the exception of strata deriving their course from the northerly bounding side of the sienite of Yell Sound, and certain strata to the west of that part of the epidotic sienite which extends from Sand Voe to Aith Voe. These rocks will be described in bringing to notice other mountain masses, possessing in like manner the character of nuclei.

(To be continued.)

Art. XII.—*Account of a Subterranean Glacier at Fondeurle, containing regular crystals of Ice* *.

The only subterranean glaciers which are generally known to exist in temperate regions, are those of Beaume in France, Tselitz in the Carpathian Mountains, and Fondeurle in the south of France. The two first of these have been slightly noticed; but, in so far as we can learn, the subterranean glacier of Fondeurle has not yet been described in our language.

The Fair of Fondeurle is the name given to a very extensive meadow, about twelve miles to the north of Die, in the department of the Drome, in the great calcareous sub-alpine range in the south-east of France. This meadow is situated above the limit of the wood, which here terminates at the height of 5147 feet above the level of the sea, and is bounded on the north and east by a high calcareous crest, while in the south it joins the Col de Quint at Fondeurle. In the month of June the Fair of Fondeurle is held upon this plain, and all the cattle dealers of the neighbouring mountains, in spite of the difficulty of access, bring hither their flocks, which have sometimes amounted to 1000 mules, 4000 cows and oxen, from 15,000 to 20,000 sheep, and from 1000 to 1200 goats.

The soil of Fondeurle is horizontal and smooth. It has the appearance of an ancient lake, which has been filled up by the detritus of the mountains; and upon careful examination it appears to cover an immense cavern, in which the brook that traverses the meadow from the east to the south is lost. If, instead of descending the Col de Quint, we turn to the left of the Fair, we discover numerous and extensive caverns, several of which have been destroyed, and whose ruins produce the most curious and extraordinary effects. The whole surface of the mountain, indeed, from the Fair of Fondeurle to the Wood of Vascieux to the east, presents the same appearance: and we witness only calcareous strata torn down and distorted, heaps of stones, clefts, gulfs, and large alpine meadows overturned and deposited in one mass of desolation.

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* This account of the Glacier of Fondeurle was given by M. Hericart de Thury, in a MS. Mineralogical Tour in the South of France. An extract from this MS. was first published in the *Journal des Mines*, vol. xxxiii. p. 157.

One of the caverns of this singular place is called the *Glacier of Fondeurle.* It has two large openings, one to the east and the other to the west. It slopes gently to the north, and probably communicates with other subterranean cavities on a lower level. The cavern of the glacier is nearly 200 feet deep, with great irregularity in its width. A rock more than 66 feet thick forms its roof. The interior is decorated with beautiful calcareous stalactites, which in some places descend from the roof to the ground, while the floor is variegated with cones of calcareous alabastrite, which sometimes overtop and shoot out from a sheet of ice of the most perfect transparency. From the vault of the cavern are suspended a great number of stalactites of limpid ice, several of which reach the floor, and lose themselves in the icy pavement. The frozen stalactites are insulated in the middle of the cavern, while those of alabaster are sustained upon its flanks, and form, by the union of their surfaces, the finest folds of a rich drapery. One of the travellers who accompanied M. Hericart de Thury to this cavern, having cut a pillar of ice, placed in the inside of it the light which he carried. The cavern was instantly illuminated with various brilliant tints of yellow, blue, green, and red, and the eyes of the spectators were dazzled with the magical effects of the reflected rays playing upon the floor of ice, upon the pillars of alabaster, and upon the great stalagmites which lined the walls of the cavern. Their admiration, however, was still greater, when, having detached some of the stalactitical pillars of ice, they found them hollow, and forming geodes or drusy cavities, the interior of which was studded with the finest crystals of ice. This unexpected appearance induced them to examine more narrowly the pavement of ice upon which they trod, and they were surprised to find it composed entirely of crystallized portions, of the most perfect transparency, presenting, for the most part, hexahedral prisms, whose terminal surface was covered with striæ parallel to the faces of the prism; while the crystals in the interior of the stalactites were sometimes triangular prisms, and sometimes hexahedral prisms, occasionally striated like those in the floor. Some of these crystals, which had a diameter of

0.005 of a millimetre, presented facets which replaced the terminal edges, that formed the junction of the prism with its base. They could not, however, discover any crystals with pyramidal summits *.

Having thus examined the form of the icy crystals, the travellers resumed the lights; and having placed them in the most clear and best crystallized parts of the cavern, they congratulated themselves in having produced, amid the ruins of the caverns of the desert of Fondeurle, an effect worthy of all that the magical palaces of the Thousand and one nights could present to the richest and most brilliant imagination.

The floor of ice is occasionally dug up, and carried to the nearest towns, and even to Valence, which is more than two leagues distant.

Art. XIII.—*Observations on the Natural History of the Sertularia gelatinosa of Pallas.* By John Fleming, D.D. F. R. S. E. and M. W. S. Communicated by the Author.

Although the penetrating genius and perseverance of Ellis elucidated the characters of many species of Sertulariæ which occur on our shores, much yet remains to be done, in order to complete the history of this beautiful tribe of zoophytes. Since the days of our British Lynceus, however, few observers have turned their attention to the study of these animals, so as to make us acquainted with new species, or to extend our knowledge of the economy and distribution of those which have already been described.

In 1800, Mr Adams published a description of what he considered a new species, and which he termed *S. imbricata,* in the 5th Vol. of the Linnean Transactions, p. 11. Tab. 2. fig. 5.—11. M. Lamouroux, however, in his valuable work

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* Hexahedral crystals of ice have also been observed by M. Hassenfratz and Mr Scoresby; and we have been informed by Mr Scoresby, that when thick masses of ice were left to thaw upon deck, they always presented the rude outline of six-sided prisms. Romé de Lisle, M. d'Antic, and Mr Scoresby, have also detected octahedral crystals, formed of two four-sided pyramids. These crystallisations are strictly conformable to the optical structure of ice, as ascertained by Dr Brewster. See *Phil. Trans.* 1818, p. 211., and *Edin. Encycl.* Art. Ice.

"Histoire des Polypiers coralligènes flexibles," p. 184. appears to entertain doubts of its animal nature, and to consider it as belonging to the tribe of sea-weeds. The imperfect description, and the indistinct figures which are given in illustration of its characters, justify such suspicions, and point out the necessity of a new examination of the species, before its station can be assigned with any degree of confidence.

The *Sertularia pennatula* of Ellis, (Zooph. p. 56. Tab. vii. f. 1, 2.), supposed to be an oriental species, is a native of the shores of Devonshire. This discovery we owe to the late George Montagu, Esq. well known as the author of Testacea Britannica, and the Ornithological Dictionary, who, in a letter dated 27th December 1808, informed me of the circumstance, and subsequently transmitted a very fine native specimen. This celebrated zoologist had paid great attention to the zoophytes of the English shores; so that his death, which took place while arranging the information which he had collected during a long period of active research, may be regarded as a national loss. In consequence of my entreaties, he composed the paper on British Sponges, which appeared in the Memoirs of the Wernerian Society, Vol. ii. Part 1. and which exhibits the fruits of much industry and acuteness. Had life been spared, it was his intention to have methodised his observations on the Linnean genus Alcyonium, of which, from his letter, dated 2d November 1811, it appears that he had determined nearly forty British species! Fortunately for the interests of science, his valuable collection was purchased by the public, and now forms a part of the British Museum; so that we may look with confidence to Dr Leach, the zealous and intelligent zoologist to that establishment, for an account of the numerous rare and undescribed species which it contains, the monuments of the merits of his deceased countryman.

In the month of November 1808, I observed a new species of Sertularia among the refuse of the oyster-boats at Newhaven, and, in the following year, I found the same species, both at Aberbrothick and in Zetland. It approaches, in its structure, the S. verticillata of Ellis's Corallines, p. 2. No. 20. Tab. xiii. fig. a A, but differs from that species, besides other characters, in its irregularly disposed, and nearly sessile cups. Having communicated specimens of this zoophyte to my scientific friend and correspondent, Mr Montagu, he recognised it as a species which he had found on the shores of Devonshire, and on which he was disposed to bestow the trivial name *dumosa.*—But I cannot, at present, enter into the details of the history of this or other new species, having already wandered far from the object of the present communication, in which I proposed to myself to give a description of the Sertularia gelatinosa of Pallas, with some remarks on its history and economy.

S. gelatinosa. Stem composed of tubes; branches in pairs, divaricate, sub-alternate; denticles on foot-stalks, alternate, bell-shaped.

Corallina filiformis ramosa pedunculis calyculorum contortis. Ellis's Corallines, p. 23. Tab. xii. f. c. C., Tab. xxxviii. f. 3. B, C, R.

Sertularia gelatinosa. Pallas, Elenchus Zoophytorum, p. 116. No. 67.

The *base* of this Sertularia, by which it adheres to stones, is spreading and spongy, and consists of numerous closely interwoven tubular fibres, which rapidly approach to form the stem.

The *stem* rises to nearly a foot in height, and is so flexible as to move with every agitation of the water. It is thickest at the base, where it consists of numerous tubes; but as these diminish in number, until, at the top, there can only be perceived a single branched thread, it tapers gradually to a point. It is nearly straight throughout, and is seldom divided.

The *branches* are disposed round the stem in nearly an alternate order, and as they are longest towards the base, and gradually diminish in length towards the summit, a graceful tapering outline is produced. They occur in pairs, which have their origin nearly at the same point. They are not formed from the external tubes, as in some of the other Sertulariæ with compound stems, but from the central ones, those at the surface turning aside to admit their exit. These branches proceed from the stem in nearly a perpendicular direction, and diverge from each other at an angle of about 45°. Each branch is acutely conical, giving out, towards the base, subordinate branches, likewise in pairs, similar to those on the main stem; at last these become alternate, and, gradually shortening, the subordinate stem supports only alternate denticles, and either terminates in twin denticles, in a single one, or in a clavate mass, containing the rudiments of a future denticle and polype.

The *denticles* are terminal, and are supported on short foot-stalks which issue from the stem in an alternate order. They are bell-shaped, somewhat produced, with an entire margin.

The *vesicles* are ovate, approaching to cylindrical, with a contracted truncated mouth, covered with a hemispherical lid. They are solitary, nearly sessile, and arise in the divisions of the branches or of the foot-stalks of the denticles. At the point of separation of the larger branches there is usually a small twig, supporting two or three denticles with vesicles.

The stems are of a brownish colour, opake, and of a firm tough consistence, but in approaching the extremities they become soft, colourless and transparent, so that the central stem of the polype can be easily distinguished. Immediately above every division, whether formed by a branch or foot-stalk, there are several transverse wrinkles, varying in number, being seldom fewer than three, or more than six. Similar wrinkles occur on the foot-stalks at the base of the denticles. The stems, at the divisions of the branches, are a little thickened, while the foot-stalks at the base of the denticles are slightly attenuated.

The body of the *polype* is distinctly visible through the transparent covering. In the branches it is somewhat dusky, but becomes paler towards the denticles. The foot-stalk of the polype, which corresponds with the foot-stalk of the denticle, is narrow, but it suddenly enlarges in the denticle to form the body, nearly of the same shape with its covering, at the summit of which the tentacula are disposed in a circle. These are about twenty in number, linear, blunt at the extremity, and divided into about ten rough raised joints. Above the circle of tentacula there is a globular head, containing the mouth. The polypes are not very irritable; for, even when pricked with a needle, they seldom retreat completely within their covering, and when left at rest, soon expand themselves, the summit of the body becoming even with the margin of the denticle, and the tentacula diverging or folding backwards on its external surface. When in an active state, I have observed the water taken in at the mouth descend, for the space of several seconds, through the gelatinous parenchyma of the body and foot-stalk, and again return to be ejected. The fluid thus circulating, did not seem to move in a solid body through tubular vessels, but to be divided into minute globules, which permeated a cellular structure.

In general, there are several principal stems adhering to the same stone, and a few younger ones springing up at their base. In the situation in which I have observed them, they are never permitted to outlive the winter, being cut off during that season by the drifted ice. They appear to be very common in the Tay above Balmerino, towards Flisk beach. It is at this latter place only where I have observed them *in situ*. Here the water is brackish, and its other conditions, as influenced by the tide, have been detailed in my paper on the "Junction of the fresh water of rivers with the salt water of the sea," in the Trans. of the Royal Soc. of Edin. vol. viii. p. 507,–513.

This species is vivacious, the polypes bearing to be kept out of the water for more than a day without perishing. It is indeed a littoral species, living in places left dry every tide. When kept in water, without being changed, the polypes soon contract within the denticles, and the body of the polype ceases to be visible in the stems. In some specimens, which I had neglected for upwards of a fortnight, the water not having been renewed during that time, I found all the polypes in the denticles shrivelled up, and numerous white threads projecting from the branches. Upon examining the origin of these threads, I found that some of them proceeded from the base of the stems, but in general they were formed from an elongation of the foot-stalk of the denticle, its cup having disappeared. The filaments consisted, as in the stalks from which they proceeded, of a soft covering, and a contained medullary cord. The extremities of these filaments were club-shaped; and soon assuming the form of a denticle, gave opening to the tentacula of a polype which had been formed within. The base of this new denticle was annulated, as in the older ones.

In the same pools with this Sertularia, may be observed the *Tubularia ramosa*, and a Flustra which does not appear to have been described. The latter I first found in 1806 on Leith shore. It differs from all the other British parasitical species, as *pilosa*, *dentata*, *lineata* and *membranacea*. The F. *bullata* of Solander and from him copied by Stewart and Turton, is merely the *Cellipora pumicosa* in its perfect state. This new species, which I have termed F. *unicornis*, spreads its thin crust on fuci and stones. The cells are contiguous, oval, with a blunt conical process at the summit of each. It often covers the stem of the older specimens of this Sertularia. Both the Sertularia and Tubularia are much infested with several species of *Vorticellæ*, among which the beautiful *V. polypina* is preeminently conspicuous. A small species of *Coryna* has likewise presented itself, whose characters have not as yet been sufficiently ascertained *.

The preceding description agrees in so many particulars with the characters which Pallas gives of his Sertularia gelatinosa, that I have adopted his trivial name without any suspicion. There is, however, one point of difference on which it is necessary to make a few remarks. Pallas, when describing his species, says (Elenchus Zoophytorum, p. 117.) of the mouth of the denticle, "margine eleganter crenato," while, in the species which I have described, the margin is plain and even. But, from the variety of aspects in which I have viewed the denticles, in reference to the structure of their mouth, and having used different magnifying powers, I am satisfied that their margins are even, and suspect that Pallas has been misled by some appearances which likewise presented themselves to me in the course of observation. The polype frequently retreats into the denticle only imperfectly, leaving the extremities of the tentacula visible above the margin, thereby giving it the appearance exhibited by the S. volubilis, in Ellis's Cor. Tab. xiv. f. A. It is only when pricked with a needle, or left without water for a short time, that it retreats completely within the cell, and permits the margin to be viewed distinctly; precautions which, it is probable, Pallas did not adopt. Besides, the numerous vorticellæ which occupy the surface and margins of the denticles, give to the latter in certain combinations a crenated appearance.

Upon comparing the characters which this Sertularia presents, with the different figures in Ellis's Corallines, I am led to consider Tab. xii. f. c C, and Tab. xxxviii. fig. 3., as representations of young specimens of the same species. These figures were certainly never drawn from specimens of S. *geniculata*, partially figured at Tab. xii., No. 19. b B, to which Ellis himself was disposed to refer them, and in which opinion he has been followed by Pallas; nor from S. *dichotoma*, with which Solander (Zooph. p. 49.) assimilates them; for the two species, although belonging to the same natural genus, are specifically distinct. From having examined this Sertularia in various stages of growth, and having seen it assume exactly the appearances which Ellis delineates, (with the exception of not having noticed the young polypes in the act of issuing from the vesicles,) I am convinced of the propriety of adding to the S. gelatinosa of Pallas, the references to the figures of Ellis which have been quoted.

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* In the month of August 1817, I observed two species of Corynæ alive in the sea at the Isle of May, the C. *squamata*, and C. *glandulosa* of Lamarck. Professor Jameson found the former species in the Zetland Islands in 1798; and I have specimens which I picked up at Abercorn in 1806.

This species forms a part of the new genus LAOMEDEA of Lamouroux, in the work already quoted, with a note subjoined, " an hujus generis?" To this question it is not very difficult to return a satisfactory answer. If either the Laomedea *antipathes*, which he first describes and figures, or the L. (Sertularia) *spinosa*, Ellis's Cor. Tab. xi. No. 17., which he quotes, be considered as the type of the genus, then the Sertularia gelatinosa does not belong to it. But it is related to this genus, if these species and others analagous be ejected, and L. (Sertularia) *dichotoma* and *geniculata* be retained; for with these it has many points of resemblance, agreeing in the pedunculated denticles, and axillary vesicles. The Sertularia *muricata*, which he has likewise appended in the same genus, presents characters very distinct from all those with which it is associated. I possess a new species nearly related to the latter, from Loch of Belfast, given to me by Mr Templeton of Orange Grove, a gentleman well known as an accomplished botanist, and to whom the British Fauna is indebted for the Ephydatia (*Spongia*, Lin.) canalium, examples of which I have likewise obtained, which he found adhering to the wall of the lock of the canal above Lisburn, 22d September 1810.

While some Sertulariæ, having stems consisting only of a single tube, are able to support themselves such as S. abietina; others, equally simple in structure, require the support of other bodies, as the S. volubilis; while in a third tribe, several tubular stems are united for mutual support, in such a manner, as to produce a compound stem, equally uniform in its outline, and symmetrical in its arrangement, as those in which the stem is simple,—such as S. verticillata, halecina and gelatinosa. But, along with these differences of structure, there is no corresponding arrangement of denticles and vesicles, so that this character which appears at first sight natural, is in reality but of subordinate importance.

The S. gelatinosa is not recorded as British by Berkenhout or Turton. It is noticed as such, however, by Stewart, in his Elements of Natural History, p. 444, without any reference or authority. Pallas indeed quotes, "Corallina confervoides, gelatinosa alba, geniculis crassiusculis, pellucidis, Ray, Syn. p. 34. No. 7.," as synonimous with his S. gelatinosa. Ellis considers the species of Ray as the S. spinosa. We suspect that Ray referred to neither of these species, but to the S. geniculata, with which his characters strikingly correspond. It is not probable, that so acute a naturalist would have omitted the distinctive characters of the species which we have been considering, had it ever come under his inspection.

As soon as circumstances permit, it is my intention to submit the genera and species of British Zoophytes to a critical examination, for the purpose of extricating them from the confusion in which they are involved, adding to their number several undescribed species which I possess, and preparing for the investigation of the extinct races which occur in a fossil state in the strata of Scotland.

MANSE OF FLISK,
26th October 1819.

ART. XIV.—*An Account of a Map of the Countries subject to the King of Ava, drawn by a Slave of the King's Eldest Son.* By FRANCIS HAMILTON, M. D. & F. R. S. & F. A. S. Lond. & Edin. Communicated by the Author *.

DURING my residence in the Empire of Ava, from the 19th of March until the 27th of November 1795, I procured from the natives several maps of their country. These, as might be expected, were very deficient in accuracy; but I found the people wonderfully quick in comprehending the nature of our maps; and some of them, to whom I could render the occupation advantageous, very soon improved their plans, and produced drawings, which have tended to throw much light on the geography of what, in the 7th volume of the Universal History (London, 1759, 8vo,) is called the *Farther Peninsula of India.* A copy of these maps, together with all the geographical information which I procured during my stay, was communicated to the Governor-General, and used by the late Mr Dalrymple in constructing the map published by Captain Symes in his Account of the Journey to Ava. Mr Arrowsmith, in his map of Asia, has followed Mr Dalrymple. In this map, the general outline of the sea-coast, the southern boundary of China, and the eastern boundary of Bengal, may be considered as fixed with tolerable accuracy; while the course of the great river to the capital of Ava, has been determined by the survey of Mr Wood. A survey by the same gentleman, fixing a considerable portion of the Brahmaputra's course, has been introduced by Mr Arrowsmith in his map of Asam, and serves to throw much light on the northern extent of the *Farther Peninsula.* The general outline of this region, together with the sources and mouths of many considerable rivers, has been thus fixed with a considerable degree of accuracy; while the detail of the interior remained to the utmost uncertain and inaccurate, as will appear from the account given in the Universal History, where every thing known, at the time when it was published, has been collected with great care and judgment. It was at one time my intention to have wrought up my materials on a scale larger than Mr Dalrymple's, and perhaps I may still do so; but in the mean time, I think it may be interesting to publish some of the original maps, exactly as drawn by the natives, but reduced to as small a scale as can be done consistent with exactness. Together with the maps, I shall add some short explanations, that may appear necessary to render them intelligible to European men of science.

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* This map will be given in next Number, along with the conclusion of the Memoir.

Some of the persons who furnished me with the maps, were afraid, or, to enhance their reward, pretended to be afraid, that their conduct might give offence to their governors, on which account they rubbed out most of the names, as written in the proper character, lest their handwriting might discover them. I was therefore under the necessity of writing the names in a hurried manner, trusting alone to the ear, which is very fallacious; but as several of my authorities did not judge this precaution necessary, and as many of their words were not rubbed out with much care, I have found means, by the assistance of an intelligent native of Dawæ, with whom I met at Calcutta, to restore almost every name to its proper character; and this, while at Amarapura, I learned to read and write, by the assistance of a young man, son of the officer appointed by the king to supply the wants of the embassy to which I belonged. At one time, I formed a scheme for expressing this character by our letters, and with the names thus written, the maps were first sent to Europe; but as I find that a scheme for the same purpose has gone through two editions at Rome, under the title of *Amadutii Alphabetum Barmanorum*, I think it best to follow the scheme adopted in that work, although it is more suited to the Italian than to the English pronunciation. In particular, when this scheme writes *i* before a vowel, we should read *y*; for *z* and *zh*, we should read *j* and *jh*; and for *sç* or *ch*, we should read *sh*. It must be observed, that the natives of Ava, especially men of fashion, in pronouncing *r*, almost always soften it into *y*; the *r* being seldom pronounced, except by their priests on some very solemn occasions.

The map which I now publish, contains a general view of all the territory that has been in any degree subject to the Kings of Ava, that is, of nearly the whole peninsula, Asam, Malaya, Siampa, Cochinchina, and part of Tonquin excepted. This country, in fertility, in beauty, and grandeur of scenery, and in the variety, value, and elegance of its natural productions, is equalled by few on earth, and is occupied by people of great activity and acuteness, possessed of many qualities agreeable to strangers; but the want of a hereditary nobility, to give its government stability, seems to have long held it in a state of anarchy, with sudden and cruel revolutions from the authority of one short-lived dynasty and petty tyranny to another.

Civility was first probably introduced into the peninsula by the conquering arms of the kindred nation occupying China, in the third century before the birth of our Saviour; but unfortunately, except in Tonquin and Cochinchina, this nation preserved its footing for too short a period to give a sufficient weight to those wise institutions and parental form of government, which unite the Chinese under a more stable authority, and in some measure supply the want of a hereditary nobility; although, even in China, the very frequent changes of dynasty, which naturally follow this defect, have been productive of the most dreadful sufferings. Still, however, the stability arising from a regular education, and from a gradual promotion through established degrees of power, recalls order along with the vigour of the first leaders of each new dynasty; and the portion of this education that has been communicated to Tonquin and Cochinchina, seems to have rendered the inhabitants of these kingdoms more happy than the natives of the countries detailed in this map, where the caprice of the mob, or of tyrants, without any adequate check, have been long indulged in raising from the dust the most audacious, unprincipled, and mean adventurers.

Before the arrival of the Chinese, the country seems to have been occupied by numerous rude tribes, who, like the invaders, were of the great Tartar race; and these, united with their conquerors, seem to have produced the offspring, which now constitutes the civilized portion of the nations termed by Europeans, Anamitic, Siammese, Burma, Malaya, and Pegu. These now occupy the chief towns of the peninsula, although a very large proportion of the country is still held by tribes in the original state of rudeness, unacquainted with literature, divinity, law and medicine, and in a great measure with manufactures and arms, but very industrious cultivators of the soil, and inoffensive in their manners.

At a later period than the Chinese invasion, along with the religious doctrines of the Buddhas, most of the civilized tribes received the literature of the Hindus, such as it existed under the kings of Magadha. On this account, in the *Alphabetum Barmanorum*, their sacred language, a dialect of the Sangskrita, is called Magata, as well as Pali, the latter name being that of one of the chief tribes of the Gangetic empire, which communicated its name to Paliputra, (Palibotra *Plinii*,) once its capital, although this tribe is now chiefly confined to the district of Dinajpur, and from its obstinate adherence to old customs is reckoned impure. Of course, the people of the peninsula, although they have adopted much of the ancient language, and many doctrines and customs of the original Hindus, with some intermixture of breed from the intercourse with the propagators of these doctrines, yet being originally of a different extraction, and adhering more violently than the Pali, not only to doctrines now obsolete, but to many of their original customs, they are, by the present occupants of Hither India, held utterly abominable. The Hindu science thus introduced, having had the effect of banishing the Chinese, although it introduced a more perfect form of writing, seems to be the cause why the western states of the peninsula are less civilized than Cochinchina and Tonquin; for although all have adopted the faith of the Hindu Buddhas, yet the two latter states have received this doctrine through Thibet and China, and still retain the literature and education of the last-mentioned state, while the western regions have received their religion and policy from Ceylon.

At the time when European nations discovered the navigation to India, the Farther Peninsula seems, as at present, by the natives of Hindustan, to have been called Chin, while the Chinese empire was called Maha Chin, or Great China; and to this alone have Europeans confined the name. Nothing, indeed, can equal the confusion that arises in the study of this peninsula's geography, from the variety of names given by different people to the same countries and places. Those contained in the map, are entirely such as are used by the Burmas or Mranmas; but I shall hereafter endeavour to explain the synonymes. In the mean time, I shall only remark, that, even among the Mranmas, almost every place of great note has two names, one in the vulgar tongue, or, as Homer would have said, in the language of men, the other in the Pali Mgadha or Sangskrita, that is, in the language of the gods, or first colonists in India.

The map accompanying this, I procured from a man in great poverty, who said, that, at the time, he was a slave of Eimshe Mayn, the heir-apparent of the kingdom, and who probably had been reduced to the servile state by debt, as his intelligence and manners denoted a person who had held considerable rank, and received a good education. Before he succeeded so far as he has done, he made several attempts, with less success; and the nature of our maps, together with the manner of laying down places by bearing and distance, had been repeatedly explained to him.

In this map, the then boundary of the empire of Ava is marked by interrupted lines, while the country properly belonging to each subjected nation is distinguished by dotted lines. Mountains are represented by a straight line, like the plain on which they stand, while a waved line represents their summits. This map is chiefly useful, as showing the connection and relative position of the different nations occupying the peninsula; for the outline has many great defects. The extent from east to west is much too great in proportion to the length from north to south; and the peninsulas projecting to the south especially, are very much curtailed, the Gulf of Siam and the Malaya peninsula being altogether omitted. The former omission especially occasions a most enormous distortion, making the course of the Cambodia river shorter than that of Siam. The countries, again, to the north of the capital, are too much extended. Little attention can, therefore, be paid to the bearings and distances in this map, at least in the parts remote from the centre, and especially in those east from the river of Siam.

Cities in this map are denoted by squares, those which have been the seat of empire having within a smaller square or dot, and those which are the seat of tributary princes having within a cross. I have to regret, that the person who constructed the map, was interrupted while I was writing the names in European character, and, being afraid of detection, rubbed out his own writing before my operation was completed; so that several places, which might have served to fix boundaries in other maps, stand in this without names.

As the towns in the central parts are in many places so near each other, it is impossible to insert their names in the reduced form of the map; but they may be found by a reference from the numbers to the following list.

List of Towns in the Country of the Kasi Shan.

1. Main Ghain.
2. Main Guæ.
3. Main Daun.
4. Zanda.
5. Tamansæ.
6. Kasa.
7. Saundut.
8. Kale.
9. Seven villages of Mresin.

Towns in the Mranma Country, North of Ava.

1. Zabbæhnago.
2. Ngarangæh.
3. Kosandi.
4. Zibouttara.
5. Mredu.
6. Dibaræn.
7. Moutzhobo.
8. Kiomraun.
9. Badoun.
10. Zingu.
11. Amræn.
12. Madara.
13. Taunbioun.
14. Zikkain.
15. Amarapura.

Towns in the Country of the Mranmas, South of Ava.

1. Great Pughan.
2. Thabæ.
3. Pænia.
4. Mækkhara.
5. Taloup.
6. Taundo.
7. Mrænzain.
8. Prænzi.
9. Shue Mænwun.
10. Paunian.
11. Pænlæ.
12. Gnaunoup.
13. Pugan.
14. Pouppa.
15. Kiaukzauk.
16. Pændalæ.
17. Meittila.
18. Sækkhara.
19. Flaindæk.
20. Gnaunran.
21. Paen.
22. Iændo.
23. Wadi.
24. Batta.
25. Mrosit.
26. Nammo.
27. Mrola.
28. Taunduængri.
29. Ramisæn.
30. Prin.
31.
32. Rase, or Sæhrekattara.
33. Shuedaun.
34. Taunu.

Towns in the Country of the Mrelap Shan, or Shanwa.

1. Taunbain.
2. Main Loun.
3. Seinni.
4. Sounzhæh.
5. Sibo.
6. Main Doun.
7. Main Gain.
8. Rapzauk.
9. Main Piein.
10. Læhkhia.
11. Puefla.
12. Gnaunrue.
13. Monæh.
14. Sigiit.
15. Naunmun.
16. Kiainkoun.
17. Zaga.
18. Kiaingan.
19. Mobræh.
20. Junzalæn.

(To be continued.)

ART. XV.—*Table of Proportional Logarithms to Twenty-four Hours, with the method of using it.*

THE following small Table of Proportional Logarithms to Twenty-four Hours, is peculiarly adapted to reducing the sun's right ascension or declination, and the equation of time, all given in the Nautical Almanack for noon at Greenwich, to any other hour on that or a different meridian.

It will be found in practice, that this table gives the corrections, (which are perpetually required, both at sea, and fixed observations,) not only more readily, but with less chance of error, than any of the tables for the same purpose, in the popular works on navigation.

This table was printed in a Calcutta magazine in 1816, and, as far as I know, has not appeared anywhere else; nor have I been able to learn the name of the industrious computer, who certainly merits the thanks of the practical navigator and astronomer. VEGA.

Proportional Logarithms to Twenty-four Hours.

This Table is useful for finding the proportional part of the daily variation of the Sun's right ascension, and declination; and of the equation of time, for any hour after noon. The numbers at the top to 24, are for hours; and at the side minutes: or the first are minutes, and those at the side seconds. The top arguments are carried on to 30, as the daily variation of the equation of time exceeds 30ˢ on some days in December.

The proportional logarithms in this Table, are found by subtracting the logarithms of the minutes in the several arguments, from the logarithm of the minutes in 24 hours, viz. 3.15836. So that the proportional logarithm of 24 becomes = 0. For the proportional logarithms above 24, the arithmetical complements of the logarithms of the arguments have been added to 3.15836, which renders it necessary to subtract 1 from the index of the result for every proportional logarithm taken from this part of the Table.

RULE.

To the proportional logarithm of the daily variation, add the proportional logarithm of the time from noon; the sum is the proportional logarithm of the correction for that interval, to be added or subtracted according as the element employed is increasing or decreasing.

When one or both the terms are small, and, consequently, their proportional logarithms great, it is convenient, in order to prevent the answer falling near the beginning of the Table, where the differences are large, to take 1 or 2 from the index of the result, which will bring the answer out 10 or 100 times too great: this is readily done by the eye.

The value of the terms of the answer is regulated by that of the arguments used; and though on this point, at first an occasional ambiguity appears to occur, it is easily removed by a due consideration of the question.

Daily Differences.

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Tenths	20	21	22	23	24	25	26	27	28	29	30	M. or S.	Tenths.
	792	580	378	185	0000	9823	9652	9488	9330	9178	9031	0	
	788	577	375	182	9997	9820	9650	9486	9328	9176	9028	1	
	785	573	371	179	9994	9817	9647	9483	9325	9173	9026	2	
	781	570	368	175	9991	9814	9644	9480	9323	9171	9024	3	
	777	566	365	172	9988	9811	9641	9478	9320	9168	9021	4	
	774	563	361	169	9985	9808	9638	9475	9318	9166	9019	5	
.1	770	559	358	166	9982	9805	9636	9472	9315	9163	9016	6	.1
	767	556	355	163	9979	9802	9633	9470	9312	9161	9014	7	
	763	552	352	160	9976	9799	9630	9467	9310	9158	9012	8	
	759	549	348	157	9973	9797	9627	9464	9307	9156	9009	9	
	756	546	345	153	9970	9794	9625	9462	9305	9153	9007	10	
	752	542	342	150	9967	9791	9622	9459	9302	9151	9004	11	
.2	749	539	339	146	9964	9788	9619	9456	9300	9148	9002	12	.2
	745	535	335	144	9961	9785	9616	9454	9297	9146	8000	13	
	741	532	332	141	9958	9782	9614	9451	9294	9143	8997	14	
	738	528	329	138	9955	9779	9611	9448	9292	9141	8995	15	
	734	525	326	135	9952	9777	9608	9446	9289	9138	8992	16	
	731	522	322	132	9949	9774	9605	9443	9287	9136	8990	17	
.3	727	518	319	129	9946	9771	9603	9440	9284	9133	8988	18	.3
	724	515	316	125	9943	9768	9600	9438	9282	9131	8985	19	
	720	511	313	122	9940	9765	9597	9435	9279	9128	8983	20	
	716	508	309	119	9937	9762	9594	9433	9277	9126	8980	21	
	713	505	306	116	9934	9760	9592	9430	9274	9124	8978	22	
	709	501	303	113	9931	9757	9589	9427	9271	9121	8976	23	
.4	706	498	300	110	9928	9754	9586	9425	9269	9119	8973	24	.4
	702	495	296	107	9925	9751	9583	9422	9266	9116	8971	25	
	699	491	293	104	9922	9748	9581	9419	9264	9114	8969	26	
	695	488	290	101	9919	9745	9578	9417	9261	9111	8966	27	
	692	484	287	98	9916	9742	9575	9414	9259	9109	8964	28	
	688	481	283	94	9913	9740	9572	9411	9256	9106	8961	29	
.5	685	478	280	91	9910	9737	9570	9409	9254	9104	8959	30	.5
	681	474	277	88	9907	9733	9567	9406	9251	9101	8957	31	
	677	471	274	85	9905	9731	9564	9403	9249	9099	8954	32	
	674	468	271	82	9902	9728	9561	9401	9246	9096	8952	33	
	670	464	267	79	9899	9725	9559	9398	9243	9094	8950	34	
	667	461	264	76	9896	9723	9556	9396	9241	9092	8947	35	
.6	663	458	261	73	9893	9720	9553	9393	9238	9089	8945	36	.6
	660	454	258	70	9890	9717	9551	9390	9236	9087	8942	37	
	656	451	255	67	9887	9714	9548	9388	9233	9084	8940	38	
	653	447	251	64	9884	9711	9545	9385	9231	9082	8938	39	
	649	444	248	61	9881	9708	9542	9383	9228	9079	8935	40	
	646	441	245	58	9878	9706	9540	9380	9226	9077	8933	41	
.7	642	438	242	55	9875	9703	9537	9377	9223	9075	8931	42	.7
	639	434	239	52	9872	9700	9534	9375	9221	9072	8928	43	
	635	431	235	48	9869	9697	9532	9372	9218	9070	8926	44	
	632	427	232	45	9866	9694	9529	9369	9216	9067	8924	45	
	628	424	229	42	9863	9691	9526	9367	9213	9065	8921	46	
	625	421	226	39	9860	9689	9523	9364	9211	9062	8919	47	
.8	621	418	223	36	9858	9686	9521	9362	9208	9060	8916	48	.8
	618	414	220	33	9855	9683	9518	9359	9206	9057	8914	49	
	614	411	216	30	9852	9680	9515	9356	9203	9055	8912	50	
	611	408	213	27	9849	9677	9513	9354	9201	9053	8910	51	
	608	404	210	24	9846	9675	9510	9351	9198	9050	8907	52	
	604	401	207	21	9843	9672	9507	9349	9196	9048	8905	53	
.9	601	398	204	18	9840	9669	9505	9346	9193	9045	8902	54	.9
	597	394	201	15	9837	9666	9502	9343	9191	9043	8900	55	
	594	391	197	12	9834	9663	9499	9341	9188	9041	8898	56	
	590	388	194	9	9831	9661	9496	9338	9186	9038	8895	57	
	587	384	191	6	9828	9658	9494	9336	9183	9036	8893	58	
	583	381	188	3	9826	9655	9491	9333	9181	9033	8891	59	
.10	580	378	185	0	9823	9652	9488	9330	9178	9031	8888	60	.10

Edin

Proportional Logarithms to Twenty-four Hours, for correcting the Daily Differences.

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Tenths.	M. or S.	H. or M. 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	M. or S.	Tenths.
	0		1.3802	1.0792	9031	7782	6812	6021	5351	4771	4260	3802	3388	3010	2663	2341	2041	1761	1498	1249	1015	792	580	378	185	0000	9823	9652	9488	9330	9178	9031	0	
	1	3.1584	1.3730	1.0756	9007	7764	6798	6009	5341	4762	4252	3795	3382	3004	2657	2336	2036	1756	1493	1245	1011	788	577	375	182	9997	9820	9650	9486	9328	9176	9028	1	
	2	2.8573	1.3660	1.0720	8983	7745	6784	5997	5331	4753	4244	3788	3375	2998	2652	2331	2031	1752	1489	1241	1007	785	573	371	179	9994	9817	9647	9483	9325	9173	9026	2	
	3	2.6812	1.3590	1.0685	8959	7728	6769	5985	5320	4744	4236	3781	3369	2992	2646	2325	2027	1747	1485	1237	1003	781	570	368	175	9991	9814	9644	9480	9323	9171	9024	3	
	4	2.5563	1.3522	1.0649	8936	7710	6755	5973	5310	4735	4228	3773	3362	2986	2641	2320	2022	1743	1481	1233	999	777	566	365	172	9988	9811	9641	9478	9320	9168	9021	4	
	5	2.4594	1.3455	1.0615	8912	7692	6741	5961	5300	4726	4220	3766	3355	2980	2635	2315	2017	1738	1476	1229	996	774	563	361	169	9985	9808	9638	9475	9318	9166	9019	5	
.1	6	2.3802	1.3388	1.0580	8889	7674	6726	5949	5290	4717	4212	3759	3349	2974	2629	2310	2012	1734	1472	1225	992	770	559	358	166	9982	9805	9636	9472	9315	9163	9016	6	.1
	7	2.3133	1.3323	1.0546	8865	7657	6712	5937	5279	4708	4204	3752	3342	2968	2624	2305	2008	1729	1468	1221	988	767	556	355	163	9979	9802	9633	9470	9312	9161	9014	7	
	8	2.2553	1.3259	1.0512	8842	7639	6698	5925	5269	4699	4196	3745	3336	2962	2618	2300	2003	1725	1464	1217	984	763	552	352	160	9976	9799	9630	9467	9310	9158	9012	8	
	9	2.2041	1.3195	1.0478	8819	7622	6684	5913	5259	4691	4188	3738	3329	2956	2613	2295	1998	1720	1460	1213	980	759	549	348	157	9973	9797	9627	9464	9307	9156	9009	9	
	10	2.1584	1.3133	1.0444	8796	7604	6670	5902	5249	4682	4180	3730	3323	2950	2607	2289	1993	1716	1455	1209	977	756	546	345	153	9970	9794	9625	9462	9305	9153	9007	10	
	11	2.1170	1.3071	1.0411	8773	7587	6656	5890	5239	4673	4172	3723	3316	2945	2602	2284	1989	1711	1451	1205	973	752	542	342	150	9967	9791	9622	9459	9302	9151	9004	11	
.2	12	2.0792	1.3010	1.0378	8751	7570	6642	5878	5229	4664	4164	3716	3310	2939	2596	2279	1984	1707	1447	1201	969	749	539	339	146	9964	9788	9619	9456	9300	9148	9002	12	.2
	13	2.0444	1.2950	1.0345	8728	7552	6628	5867	5219	4655	4156	3709	3304	2933	2591	2274	1979	1703	1443	1197	965	745	535	335	144	9961	9785	9616	9454	9297	9146	8000	13	
	14	2.0122	1.2891	1.0313	8706	7535	6614	5855	5209	4646	4149	3702	3297	2927	2585	2269	1974	1698	1438	1193	962	741	532	332	141	9958	9782	9614	9451	9294	9143	8997	14	
	15	1.9823	1.2833	1.0280	8683	7518	6601	5843	5199	4638	4141	3695	3291	2921	2580	2264	1969	1694	1434	1190	958	738	528	329	138	9955	9779	9611	9448	9292	9141	8995	15	
	16	1.9542	1.2776	1.0248	8661	7501	6587	5832	5189	4629	4133	3688	3284	2915	2575	2259	1965	1689	1430	1186	954	734	525	326	135	9952	9777	9608	9446	9289	9138	8992	16	
	17	1.9279	1.2719	1.0216	8639	7484	6573	5821	5179	4620	4125	3681	3278	2909	2569	2255	1960	1685	1426	1182	950	731	522	322	132	9949	9774	9605	9443	9287	9136	8990	17	
.3	18	1.9031	1.2663	1.0185	8617	7467	6559	5809	5169	4611	4117	3674	3271	2903	2564	2249	1955	1680	1422	1178	947	727	518	319	129	9946	9771	9603	9440	9284	9133	8988	18	.3
	19	1.8796	1.2607	1.0154	8595	7451	6546	5797	5159	4603	4110	3667	3265	2897	2558	2244	1951	1676	1417	1174	943	724	515	316	125	9943	9768	9600	9438	9282	9131	8985	19	
	20	1.8573	1.2553	1.0122	8573	7434	6532	5786	5149	4594	4102	3660	3258	2891	2553	2239	1946	1671	1413	1170	939	720	511	313	122	9940	9765	9597	9435	9279	9128	8983	20	
	21	1.8361	1.2499	1.0091	8552	7417	6519	5774	5139	4585	4094	3653	3252	2886	2547	2234	1941	1667	1409	1166	935	716	508	309	119	9937	9762	9594	9433	9277	9126	8980	21	
	22	1.8159	1.2446	1.0061	8530	7401	6505	5763	5129	4577	4086	3646	3246	2880	2542	2229	1936	1663	1405	1162	932	713	505	306	116	9934	9760	9592	9430	9274	9124	8978	22	
	23	1.7966	1.2393	1.0030	8509	7384	6492	5752	5120	4568	4079	3639	3239	2874	2537	2224	1932	1658	1401	1158	928	709	501	303	113	9931	9757	9589	9427	9271	9121	8976	23	
.4	24	1.7782	1.2341	1.0000	8487	7368	6478	5740	5110	4559	4071	3632	3233	2868	2531	2219	1927	1654	1397	1154	924	706	498	300	110	9928	9754	9586	9425	9269	9119	8973	24	.4
	25	1.7604	1.2289	9970	8466	7351	6465	5729	5100	4551	4063	3625	3227	2862	2526	2214	1922	1649	1393	1150	920	702	495	296	107	9925	9751	9583	9422	9266	9116	8971	25	
	26	1.7434	1.2239	9940	8445	7335	6451	5718	5090	4542	4056	3618	3220	2856	2520	2209	1918	1645	1388	1146	917	699	491	293	104	9922	9748	9581	9419	9264	9114	8969	26	
	27	1.7270	1.2188	9911	8424	7319	6438	5707	5081	4534	4048	3611	3214	2850	2515	2203	1913	1641	1384	1142	913	695	488	290	101	9919	9745	9578	9417	9261	9111	8966	27	
	28	1.7112	1.2139	9881	8403	7302	6426	5695	5071	4525	4040	3604	3208	2845	2510	2198	1908	1636	1380	1138	909	692	484	287	98	9916	9742	9575	9414	9259	9109	8964	28	
	29	1.6960	1.2090	9852	8382	7286	6413	5684	5061	4517	4033	3597	3201	5839	2504	2193	1904	1632	1376	1134	905	688	481	283	94	9913	9740	9572	9411	9256	9106	8961	29	
.5	30	1.6812	1.2041	9823	8361	7270	6399	5673	5052	4508	4025	3590	3195	2833	2499	2188	1899	1627	1372	1130	902	685	478	280	91	9910	9737	9570	9409	9254	9104	8959	30	.5
	31	1.6670	1.1993	9794	8341	7254	6385	5662	5042	4499	4017	3583	3189	2827	2493	2183	1894	1623	1368	1126	898	681	474	277	88	9907	9733	9567	9406	9251	9101	8957	31	
	32	1.6532	1.1946	9765	8320	7238	6372	5651	5032	4491	4010	3577	3183	2822	2488	2178	1890	1619	1364	1123	895	677	471	274	85	9905	9731	9564	9403	9249	9099	8954	32	
	33	1.6399	1.1900	9737	8300	7222	6359	5640	5023	4483	4002	3570	3176	2816	2483	2173	1885	1614	1359	1119	891	674	468	271	82	9902	9728	9561	9401	9246	9096	8952	33	
	34	1.6269	1.1852	9708	8280	7206	6346	5629	5013	4474	3995	3563	3170	2810	2477	2169	1880	1610	1355	1115	887	670	464	267	79	9899	9725	9559	9398	9243	9094	8950	34	
	35	1.6143	1.1806	9680	8259	7190	6333	5618	5004	4466	3987	3556	3164	2804	2472	2164	1876	1605	1351	1111	883	667	461	264	76	9896	9723	9556	9396	9241	9092	8947	35	
.6	36	1.6021	1.1761	9652	8239	7175	6320	5607	4994	4457	3979	3549	3158	2798	2467	2159	1871	1601	1347	1107	880	663	458	261	73	9893	9720	9553	9393	9238	9089	8945	36	.6
	37	1.5902	1.1716	9625	8219	7159	6307	5596	4985	4449	3972	3542	3151	2793	2461	2154	1866	1597	1343	1103	876	660	454	258	70	9890	9717	9551	9390	9236	9087	8942	37	
	38	1.5786	1.1671	9597	8199	7143	6295	5585	4975	4440	3964	3535	3145	2787	2456	2149	1862	1592	1339	1099	872	656	451	255	67	9887	9714	9548	9388	9233	9084	8940	38	
	39	1.5673	1.1627	9570	8179	7128	6282	5574	4966	4432	3957	3529	3139	2781	2451	2144	1857	1588	1335	1095	868	653	447	251	64	9884	9711	9545	9385	9231	9082	8938	39	
	40	1.5563	1.1584	9542	8159	7112	6269	5563	4956	4424	3949	3522	3133	2776	2446	2139	1852	1584	1331	1092	865	649	444	248	61	9881	9708	9542	9383	9228	9079	8935	40	
	41	1.5456	1.1540	9515	8140	7097	6256	5552	4947	4415	3942	3515	3127	2770	2440	2134	1848	1579	1327	1088	861	646	441	245	58	9878	9706	9540	9380	9226	9077	8933	41	
.7	42	1.5351	1.1498	9489	8120	7081	6243	5541	4937	4407	3934	3508	3120	2764	2435	2129	1843	1575	1322	1084	858	642	438	242	55	9875	9703	9537	9377	9223	9075	8931	42	.7
	43	1.5249	1.1455	9462	8101	7066	6231	5531	4928	4399	3927	3502	3114	2758	2430	2124	1839	1571	1318	1080	854	639	434	239	52	9872	9700	9534	9375	9221	9072	8928	43	
	44	1.5149	1.1413	9435	8081	7051	6218	5520	4919	4390	3920	3495	3108	2753	2424	2119	1834	1566	1314	1076	850	635	431	235	48	9869	9697	9532	9372	9218	9070	8926	44	
	45	1.5052	1.1372	9409	8062	7035	6205	5509	4909	4382	3912	3488	3102	2746	2419	2114	1829	1562	1310	1072	847	632	427	232	45	9866	9694	9529	9369	9216	9067	8924	45	
	46	1.4956	1.1331	9383	8043	7020	6193	5498	4900	4374	3905	3481	3096	2741	2414	2109	1825	1558	1306	1068	843	628	424	229	42	9863	9691	9526	9367	9213	9065	8921	46	
	47	1.4863	1.1290	9357	8023	7005	6180	5488	4891	4366	3897	3475	3089	2736	2409	2104	1820	1553	1302	1064	839	625	421	226	39	9860	9689	9523	9364	9211	9062	8919	47	
.8	48	1.4771	1.1249	9331	8004	6990	6168	5477	4881	4357	3890	3468	3083	2730	2403	2099	1816	1549	1298	1061	836	621	418	223	36	9858	9686	9521	9362	9208	9060	8916	48	.8
	49	1.4682	1.1209	9305	7985	6975	6155	5466	4872	4349	3883	3461	3077	2724	2398	2095	1811	1545	1294	1057	832	618	414	220	33	9855	9683	9518	9359	9206	9057	8914	49	
	50	1.4594	1.1170	9279	7966	6960	6143	5456	4863	4341	3875	3455	3071	2719	2393	2090	1806	1540	1290	1053	828	614	411	216	30	9852	9680	9515	9356	9203	9055	8912	50	
	51	1.4508	1.1130	9254	7948	6945	6131	5445	4853	4333	3868	3448	3065	2713	2388	2085	1802	1536	1286	1049	824	611	408	213	27	9849	9677	9513	9354	9201	9053	8910	51	
	52	1.4424	1.1092	9228	7929	6930	6118	5435	4844	4325	3860	3441	3059	2708	2382	2080	1797	1532	1282	1045	821	608	404	210	24	9846	9675	9510	9351	9198	9050	8907	52	
	53	1.4341	1.1053	9203	7910	6915	6106	5424	4835	4316	3853	3435	3053	2702	2377	2075	1793	1528	1278	1041	817	604	401	207	21	9843	9672	9507	9349	9196	9048	8905	53	
.9	54	1.4260	1.1015	9178	7892	6900	6094	5414	4826	4308	3846	3428	3047	2696	2372	2070	1788	1523	1274	1037	814	601	398	204	18	9840	9669	9505	9346	9193	9045	8902	54	.9
	55	1.4180	1.0977	9153	7873	6885	6081	5403	4817	4300	3839	3421	3041	2691	2367	2065	1784	1519	1270	1034	810	597	394	201	15	9837	9666	9502	9343	9191	9043	8900	55	
	56	1.4102	1.0939	9129	7855	6871	6069	5393	4808	4292	3831	3415	3035	2685	2362	2061	1779	1515	1265	1030	806	594	391	197	12	9834	9663	9499	9341	9188	9041	8898	56	
	57	1.4025	1.0902	9104	7836	6856	6057	5382	4799	4284	3824	3408	3028	2679	2356	2056	1775	1510	1261	1026	803	590	388	194	9	9831	9661	9496	9338	9186	9038	8895	57	
	58	1.3949	1.0865	9079	7818	6842	6045	5372	4789	4276	3817	3401	3022	2674	2351	2051	1770	1506	1257	1022	799	587	384	191	6	9828	9658	9494	9336	9183	9036	8893	58	
	59	1.3875	1.0828	9055	7800	6827	6033	5362	4780	4268	3809	3395	3016	2668	2346	2046	1766	1502	1253	1018	795	583	381	188	3	9826	9655	9491	9333	9181	9033	8891	59	
.10	60	1.3802	1.0792	9031	7782	6812	6021	5351	4771	4260	3802	3388	3010	2663	2341	2041	1761	1498	1249	1015	792	580	378	185	0	9823	9652	9488	9330	9178	9031	8888	60	.10

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EXAMPLE I.

Required the Sun's right ascension and declination, and the equation of time for noon at Edinburgh, on the 13th August 1819.

⊙ AR. noon, Green. 13th	$9^h\,29^m\,1^s.3$		Declination 14° 52′ 54″		Equation $4^m 40^s.9$	
14th	9 32 47.5		14 34 38		4 30.6	
Daily var. of AR. &c. =	3 46.2	P. L. 8039	18 16	P. L. 1185	10.3	P.L. 3674
Diff. longitude in time,	12 47	P. L. 2736		2736		2736
Correction AR. &c.	+ 2.0	1.0775	— 9″ 44‴ or — 9″.7	3921	— 5‴.5 or —0^s.1	6410
⊙ AR. noon, Greenwich,	9 32 47.5		⊙ Dec. N. Gr. 14 34 38.0		Equa. N. Gr. 4 30.6	
⊙ AR. &c. N. at Edin. 13th,	9 32 49.5		Declination 14 34 28.3		Equation 4 30.5	

EXAMPLE II.

Required the corrections at Edinburgh for the same day, at $4^h\ 15^m$ P.M.

Daily var. ⊙ AR. &c. as above.	$3^m\ 46^s.2$	P. L. 8039	18′ 16″	P. L. 1185	$10^s.3$	P.L. 3674
($4^h\ 15^m + 12^m.8$) = Green. time,	$4^h\ 27^m.8$	P. L. 7305		7305		7305
Corrections, -	+ 42″.1	1.5344	— 3′ 24″	8490	— 1.9	1.0979
⊙ AR. noon, Greenwich,	9 32 47.5		⊙ Dec. N. Gr. 14 34 38		Equa. N. Gr. 4 30.6	
⊙ AR. at $4^h\ 15^m$ P. M. Edin.	9 33 29.6		⊙ Dec. 14 31 14		Equation, 4 28.7	

ART. XVI.—*On the Optical and General Properties of Tabasheer.* By DAVID BREWSTER, LL.D. F. R. S. Lond. & Ed.

IN the First Number of this Journal, we have already given a general account of the singular substance called Tabasheer, and of its inferiority in refracting power to all solid and fluid substances hitherto examined. Since that article was published, the original paper has appeared in the Philosophical Transactions for 1819, Part II.; and as the subject is of a popular nature, and easily understood by those who have but a moderate share of optical knowledge, we have thought it right to present the reader with an abridged account of it.

Tabasheer readily imbibes all the volatile and fat oils, and indeed all the fluids that I have tried. The essential oils are quickly absorbed, and, with the exception of oil of cassia, are as quickly evaporated, while the fat oils are slowly drawn in and remain a long time in its pores; and in all these cases an opacity is produced by a partial absorption exactly as in the case of water.

When the imbibed fluids have a colour of their own, or are tinged with any colouring matter, the tabasheer exhibits a similar tint, so that it is easy to communicate to it any colour. From a solution of acetate of copper, it acquires the colour of the emerald; from oils coloured with anchusa root, it receives the tints of the ruby; from oil of beech-nut, the colour of the chrysoberyl; from sulphuric acid, that of the pink topaz; and from malic acid, that of the Brazilian topaz. These different colours may be all discharged by exposing the tabasheer to a red heat, and thus expelling the absorbed fluid to which they owe their origin.

The opaque tabasheer, which retains its opacity when its pores are filled with water, acquires the most beautiful transparency from the absorption of oil of beech-nut; and it is curious to observe a substance like chalk, and consisting apparently of a number of particles in a state of accidental aggregation, converted into a transparent mass, which the light freely penetrates in every direction. Having saturated a large piece of this kind of tabasheer with oil of beech-nut, coloured with anchusa root, I laid it on a mass of lead of a lower temperature than that of the room. The oil instantly retired from the surface of the tabasheer into its interior, and the transparent mass became opaque like a piece of red brick. Upon removing it into its former temperature, the oil returned to the surface, and the tabasheer resumed its transparency. If, on the other hand, we place it in a higher temperature than that of the room, a part of the oil will be discharged, and when it is brought back to its first temperature, it will become opaque like a piece of brick. Even when a small part of the oil remains, the transparency may be readily restored by the application of a sufficient degree of heat. The phenomena which have now been described, admit of a satisfactory explanation from the difference between the expansion of the oil and that of the tabasheer; but the effect appears to be too great to arise from this cause, and I am rather disposed to ascribe it to a variation in the capacity of the tabasheer for the oil by a change of temperature.

In order to observe the nature of the penumbral boundary which might be supposed to separate the opaque from the transparent part, if they could be both rendered visible in the same mass, I saturated the largest piece of tabasheer that I had with the coloured oil, and having discharged a good deal of it by heat, it became of course opaque. I now held to the flame of a candle one of its extremities, which immediately became diaphanous, and the transparency gradually pervaded the opaque mass. As soon as the opacity disappeared, I allowed one extremity of it to cool; the transparency immediately disappeared at that part, and the opacity gradually advanced like a black cloud, till the whole was overshadowed by the retreat of the oil into the interior of the mass. In both these cases the penumbra, which separated the opaque and transparent portions, had a ragged or branching appearance when seen by a microscope, as if the oil had been shooting into crystals during the progress of the opacity, and as if these crystals had been dissolving during its retreat.

Upon examining the appearance of the tabasheer when it had the colour of red brick, after the discharge of a portion of its oil, I was surprised to observe a beautiful veined structure, exactly like that of the agate, the veins being sometimes parallel, sometimes inflected, and sometimes curved. In some specimens the veins were alternately opaque and translucent, and in others red and white, as if one set of strata had a greater capacity for the oil than the rest. This effect is almost universal; but as soon as the oil is completely discharged, the veined structure entirely disappears, and the whole mass assumes the homogeneous appearance of chalk.

In order to observe the circumstances under which the chalky tabasheer became transparent by the absorption of oils, I cut four plates out of the same piece, and immersed them separately in oil of cassia, alcohol, water, and oil of beech-nut. The plates that had absorbed the three first of these fluids remained quite opaque, but the plate that was placed in the oil of beech nut gradually acquired a translucency by the rapid extrication of air. After a certain time it appeared to be covered with scratches and small opaque portions; but these appearances, which arose from remaining vesicles of air, vanished by degrees.

By the application of a microscope, I observed the air form itself into globules in the interior of the tabasheer, which slowly advanced to the edge of it, and at last escaped into the oil. After a lapse of nearly two hours, the greater part of the air was extricated, and the expulsion of the remainder was quickly effected by a gentle heat; but the transparency was of that imperfect kind, which results from the union of two bodies of different refractive powers. By increasing the heat, the tabasheer became more transparent, and at a certain temperature it could scarcely be seen in the oil in which it was placed. When the heat was still farther augmented, it became more and more opaque, and a corresponding opacity was induced by cooling it down as much below the temperature of maximum transparency.

When pure tabasheer is boiled for any length of time, or is brought to a red or a white heat, it suffers no change either in its colour or in its optical and physical properties: if we wrap it, however, in a piece of paper, and set the paper on fire, the tabasheer becomes either black, or brownish-black, and the black colour increases in depth by the repetition of the experiment.

If the blackened tabasheer is brought to a red heat, it is restored to its primitive whiteness, and resumes all its former properties; but if the heat is considerably below redness, some specimens acquire a slight transparency, and a dark slaty blue colour, shading in some places into whiteness. *When slightly wetted in this state, it becomes chalky white; with a greater portion of water it becomes black; and with a still greater portion it becomes again transparent.* If we break a piece of tabasheer a few days after it has received a deep black tint, we shall find that it has often a fine ash-grey colour, which becomes deeply black when wetted, and afterwards resumes its primitive tint when dry.

With the view of discovering if the blackness was owing to any vegetable matter in the tabasheer, I repeated the operation of blackening it and restoring its colour by heat about 50 times; but after all these operations, it became black as readily as at first. The specimen that had undergone these changes had increased in hardness and lustre, and had the appearance of the finest Indian ink. Upon breaking it in two, the fracture was perfectly black, but assumed a dark blue colour by exposure to the air; and upon *putting a drop of pure water upon the blue* *fracture, it was instantly converted into a deep and glossy black.*

Mr Jardine, who had the goodness to take the specific gravity of tabasheer, found that of the opaque kind to be 2.059 when dry, and 1.320 when wet; and that of the transparent kind 2.412 when dry, and 1.396 when wet.

Mr Macie found the specific gravity of a parcel of opaque and transparent tabasheer to be 2.188; and Mr Cavendish, having tried the same parcel, found it to be 2.169. The mean of Mr Jardine's results is 2.235, which exceeds the measures of Macie and Cavendish, because the opaque fragments in their parcels must have been more numerous than the transparent ones, in consequence of the rarity of the latter.

It appears from the preceding results, that in both kinds of tabasheer the quantity of water imbibed exceeds in weight that of the tabasheer itself; and that in the opaque kinds, the space occupied by the pores is to the space occupied by the tabasheer, as 2.307 to 1; while in the transparent kinds, it is 2.5656 to 1. This result indicates a very remarkable degree of porosity; and as it makes the pore more extensive in the transparent than in the opaque kind, contrary to what we should expect from their specific gravities, it seems to follow, that the water was not capable of insinuating itself into all the pores of the opaque tabasheer. This conclusion is rendered more probable, when we consider the extreme difficulty with which the oil of beech-nut displaces the last portions of included air; and it affords a very plausible explanation of the fact, that the chalky tabasheer cannot be rendered transparent by the absorption of water.

We are now prepared by the preceding observations, for investigating the cause of the remarkable paradox exhibited by the transparent tabasheer, in becoming perfectly opaque and white, by absorbing a small quantity of water, and perfectly transparent when that quantity is increased. As this effect takes place indiscriminately with all fluids, it cannot be the result of any chemical action, and therefore its cause must be sought for in the changes which the light suffers in traversing the vacuities of the tabasheer.

Let ABC, Plate III. Fig. 7. be a prism of this substance, and *a b c d* one of its pores highly magnified. We know that this pore is filled with air; and that when a ray of light MN enters the separating surface *a b* at *e*, and quits it at *h*, it suffers so little refraction, and is therefore so little scattered, that the tabasheer appears transparent, and allows us to see objects distinctly through it. This effect, which could not take place in any other porous substance, arises from the small difference between the refractive power of *air* and of *tabasheer*. Let us now suppose that a small quantity of water is introduced into the pore *a b c d*, so as not to fill it, but merely to line its circumference with a film contained between *a b c d* and $\alpha \beta \gamma \delta$. Then the light which was formerly scattered by the slight refraction at *e* and *h* in passing from tabasheer into air, will now be a little less scattered at these points, since it passes from tabasheer into water, where the difference of refractive power is less; but in passing from the film of water into the air at *f*, and in entering the water again at *g*, the scattering of the rays will be very considerable, from the great difference in the refractive powers of *air* and *water*. In passing through every pore, therefore, the light is refracted, and consequently scattered no less than four times; and hence the piece of tabasheer must appear to be opaque. If we now saturate it with water, the pore *a b c d* will be completely filled; the two great refractions which took place at *f* and *g*, will no longer exist; and the light will suffer only a slight refraction at *e* and *h*, by which it will be less scattered than when the tabasheer was dry. Hence it follows, that when the tabasheer is saturated with water, it ought to transmit the incident light freely, and to be more transparent than when it is quite dry,—a result which is perfectly conformable to observation [*].

ART. XVII.—*Account of the Ayrshire Rose.* In a Communication from Mr NEILL, Secretary of the Caledonian Horticultural Society.

FOR a number of years past, a very rampant climbing rose-bush has been cultivated in Scotland, under the name of the

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[*] The reader is referred to the original paper in the *Philosophical Transactions* for more detailed information respecting the properties of Tabasheer.

Ayrshire Rose. Such is the rapidity of growth of its long slender shoots, that one plant has been known to cover a gable-wall twenty feet high, and a side-wall of double that length, in the course of two seasons. It has therefore been much in request for covering out-houses, and disguising offensive walls or palings. It is an exotic species, but is nearly allied to our native Rosa arvensis or White Dog-rose, and has probably, indeed, in many cases been confounded with that species.

Mr Woods, in his monograph of British Roses, in the 12th volume of the Linnean Transactions, seems to unite both together, in his account of the Rosa arvensis; although, as will presently appear, the Ayrshire rose has perhaps stronger claims to be regarded as a separate species than several others considered as specifically distinct by this author, such as R. rubella and R. surculosa.

Dr Sims, the highly respectable editor of the Botanical Magazine, when publishing in that work (Pl. 2054.) a figure of what he calls Rosa arvensis var. β, observes, " It has been known some years in our nurseries under the name of the Ayrshire Rose; but upon what grounds it has been so called, is difficult to say; for, upon inquiry, we are informed no rose of the kind could be heard of there, or in any part of Scotland."

That Rosa arvensis, or a slight variety of it, may have been often sold in the London nurseries in place of the genuine Ayrshire Rose, is nowise improbable; the former being much more easily procured than the latter. But the Doctor must have been exceedingly unfortunate, indeed, in the inquiries made regarding the Ayrshire rose in Scotland; for, that species is well known, not only in the county of Ayr, but throughout Scotland wherever there is a respectable private garden or public nursery.

Before giving an account of the origin of the Ayrshire rose, or of its introduction into this country, it may be proper to detail its characters, in order to establish its title to be regarded as a distinct species; and it may be useful at the same time to premise a description of the Rosa arvensis, that the reader may thus have the characters of the two species brought into immediate contrast. In some gardens in the neighbourhood of Edinburgh, both the true Ayrshire rose and the Rosa arvensis of the Flora Britannica are cultivated. At my request, Mr David Don (son of the late eminent Mr Don of Forfar, and a very promising young botanist) has, for some time past, paid great attention to the growth and appearance of the two species, and has drawn up the following characters of each.

1. *Rosa arvensis. White Dog-rose.*—Surculis longissimis procumbentibus foliolis ovatis inæquali-serratis subtus tantum hirsutis; fructibus globosis pedunculisque nudiusculis.

Caules decumbentes, surculi longissimi procumbentes teretes lævissimi rubescentes; aculei sparsi uncinati; foliola septena ovata inæquali-serrata, supra glaberrima, subtus aliquantum hirsuta; stipulæ integræ apice acutæ margine ciliatæ, petioli supra canaliculati utrinque pubescentes; pedunculi elongati nudiusculi; fructus globosus glaber, stylis unitis antheras subæquantibus.

2. *Rosa capreolata. Ayrshire Rose.*—Surculis flagellatis procumbentibus, foliolis ellipticis æqualiter serratis utrinque glaberrimis; fructibus ovatis (collo constricto) pedunculisque glandulosis.

Caules decumbentes ramosissimi, surculi flagellati procumbentes aculei sparsi falcati; foliola septena elliptica breve acuminata æqualiter serrata utrinque glaberrima, supra nitida; rubescentes nitidi pruinati; stipulæ apice acuminatæ margine integerrimæ pilis glanduliferis ciliatæ, petioli supra canaliculati utrinque nudi; segmenta calycina subsimplicia elliptica apice cuspidata, extus glandulosa pilosa, intus tomentosa; pedunculi elongati glandulosi, petala obcordata alba; filamenta basi reclinata, apice ascendenti-inflexa, antheræ luteæ, stylis in cylindrico coalitis, stamina subæquantibus, stigmata brevissima barbata: Fructus ovatus (collo constricto) pilis glanduliferis raris adspersis; flores corymbosi.

The Rosa arvensis is common in hedges and waste grounds in England; but is comparatively of rare occurrence in Scotland.

The trivial name *capreolata*, having allusion to its climbing nature, was first applied to the other species by the late Mr Don, who cultivated it as a distinct species for many years in his curious botanic garden at Forfar. This is nearly allied to the former; but, as may be remarked from comparing the characters above given, the two species differ particularly in the following respects.

In R. capreolata, the leaflets are more shining and more elongated than in R. arvensis. In the former, they are quite smooth on both sides, and equally serrated at the margins; while, in the latter, they are somewhat hairy on the under side, and rather unequally serrated. In R. capreolata the fruit is ovate, furnished with a neck, which, along with the peduncle, presents scattered glandular hairs, more evident in the immature fruit; while the fruit of R. arvensis is globular, and every where smooth. In R. capreolata the petioles of the leaves are naked; while in R. arvensis they are pubescent. In respect to general habit, it may be remarked, that R. capreolata grows more strongly and freely than R. arvensis; and, what may be considered as rather a striking peculiarity, the former retains its leaves much longer than the latter: In short, R. capreolata inclines to be an evergreen in our climate. In this respect it is allied to R. sempervirens, or the Evergreen Rose: But this species is readily distinguished by its more leafy stems, its leaves being still more glossy, with closer serratures; and its fruit and peduncles being hispid.

I may mention, that in the Royal Botanic Garden here, both species have for some years been kept growing close by each other, so as to afford every facility for comparison, and that the excellent superintendant of the garden, Mr William Macnab, has thus satisfied himself of their being specifically distinct. He concurs generally in the accuracy of the discriminative characters above detailed; and adds a remarkable character, distinctive of the general habits of the two species: the trailing shoots of R. arvensis, at the points where they touch the ground, speedily send forth roots in the manner of the common bramble-bush; but this tendency to radication, is never observed in the shoots of the Ayrshire rose, of whatever length they may be, or however favourably applied to the surface of the ground.

I have now to offer some proof that R. capreolata is really an exotic species. I am enabled to state that it is a North American native; and, by the assistance of Mr Walter Underwood, the very intelligent gardener at Eglinton Castle, to give an account of its introduction into Scotland.

At the time when the Botanic Garden at Leith Walk, Edinburgh, was originally established, (about 1767), the late Dr John Hope, Professor of Botany, and some wellwishers to the garden and to botanical science, united in sending out a person to North America, with the view of his collecting the seeds of new, curious or useful plants. Of the transatlantic rarities sent home by this collector, no register seems to have been made; and both he and his patrons have thus in a great measure lost the credit that was due to them for their zeal. The late John, Earl of Loudon, was a subscriber towards this botanical speculation; and in return, he received, in 1768 or 1769, a share of a parcel of seeds sent either from Lower Canada or Nova Scotia. Among these were some briar heps; which being sown in the garden at Loudon Castle, produced a number of rose-bushes. These, in a year or two, attracted much notice by the great length to which they pushed their shoots. The present Mr George Douglas of Rodinghead (factor upon the Duke of Portland's estates in Ayrshire) resided at Loudon Castle at that period; and he perfectly recollects the sowing of the American heps, and the wide rambling rose-plants which sprung from them. Several of the neighbouring proprietors in Ayrshire got plants of the new rose for their gardens. Among others, the late Mr Dalrymple of Orangefield received a plant from Mr Douglas; and he having trained it against the garden-wall, "it ran amazingly," (as Mr Underwood expresses it), the rapidity of its growth, and length of the shoots, surprising every body. The nurserymen of Kilmarnock and Ayr having procured cuttings and layers from this plant, bestowed on it the name of the *Orangefield Rose;* in places at a distance, however, it soon came to be known by the more general title of the *Ayrshire Rose.* The original Orangefield specimen was in existence little more than twenty years ago; but the garden having, about that time, come into the possession of a tenant, who preferred currant bushes to rampant roses, it was grubbed up and destroyed. Several of the original plants, however, still remain at Loudon Castle, some trained against the walls of the factor's house, and others in old hedges on the farm of Alton, near Loudon. Mr Douglas has likewise some of the original plants growing in hedges, and against walls, on his own property of Rodinghead.

It must be admitted to be somewhat singular, that no rose approaching in character to R. capreolata should be described by writers on the plants of North America, especially by Pursh in his late Flora of that country. Still, it is perfectly possible that it may have been overlooked.

Whether this species be known on the Continent of Europe, does not clearly appear. It may be noticed, however, that the Rosa prostrata of the last edition of the Flore Française, is decribed as distinguished by its "shining persistent leaves," characters quite applicable to the Ayrshire Rose.

CANONMILLS,
12*th Nov.* 1819.

ART. XVIII.—*On the Depth and Temperature of the Lake of Geneva.* By Mr H. T. DE LA BECHE. Communicated by Professor PICTET *. With a Map.

I HAVE the honour of communicating to you some observations on the depth and temperature of the Lake of Geneva, which the goodness of the season has permitted me to make.

The accompanying map (Plate II.) points out the places where I sounded, and the corresponding depths. These depths are greatest on the coast of Savoy, till opposite Lausanne, where the lake becomes deepest on the side of the Canton de Vaud.

The places where the banks descend most rapidly, are the point of Drances, Meillerie, St Gingoulph, the Castle of Chillon, and Vevay. In several places, the greatest depths occur about 50 fathoms from the shore, particularly at St Gingoulph and Vevay, where the bottom again rises.

The soundings were taken with two cylindrical masses of lead, one of which weighed 10 lb. and the other 8 lb. The weight of 8 lb. was sufficient for the greatest depths, and was able to resist every current.

These currents did not frequently occur, and those which I did observe, had little velocity, excepting in the sounding of 80 fathoms, opposite the Point of Drances, where no sensible current was perceived at the surface. At the depth of 15 fathoms, a current carried the thermometer to the west; and when I had let out 10 fathoms more of cord, I perceived that another current carried it almost as rapidly to the east. None of these, however, lasted long, for, on letting out 12 fathoms more, the thermometer ceased to be influenced by any current. The boatmen informed me, that these currents were very irregular, and had all sorts of directions.

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* The observations in this paper were addressed by their author to Professor Pictet, for the *Bibliotheque Universelle.* We have abridged the preliminary remarks.—ED.

The self-registering thermometer which I used, was similar to those employed on the late Arctic Expedition. About 2 lb. of lead was always added for great depths, in order to make it descend vertically.

In observing the soundings, I at first allowed the lead to descend, and having raised it, I made it redescend two or three times, in order to ascertain that I had reached the bottom. The thermometer was then substituted in place of the lead; and after being attached to the sounding line, I sunk it to within half a fathom of the bottom in deep water, and a quarter of a fathom in smaller depths,—a precaution which was necessary, in order to prevent it from striking against the ground.

TABLE of the Depths and Temperatures of the LAKE *of* GENEVA, *in the different places indicated on the Map* (Plate II.) *which accompanies this paper.*

Dates.		Depth.	Temp.	Dates.		Depth.	Temp.
1819.		Fath.	Fahr.	1819.		Fath.	Fahr.
Sept. 15.	From Geneva to Genthod,	1	67°	Sept. 15.	From Bellerive to Geneva.	26	46°
		2½	66			20½	52
		4½	65			5	65
		5	65			1½	67
		7	64	16.	From Geneva to Bellerive.	3½	64
		10	62			6	63
		12½	58			11	58
		15	54			12	58
		18	53	20.	From Bellerive to Copet.	14	55
	From Genthod to Bellerive,	24	50			23	45
		27½	45			34	44
		28½	45			30	45
						8	62

Dates.		Depth.	Temp.
1819.		Fath.	Fahr.
Sept. 20.	From Copet to Hermance.	5	65°
		15	55
		19	52
〃	Fom Bellerive to Messeri,	23	46
		35	44
		38	44
		35	44
		33	44
		28	45
		26	45
		25	45
		18	57
〃	From Messeri to Nion.	16	61
		35	44
		40	44
		40	44
		32	45
		27	48
		23	51
		13	57
26.	Fr. Nion to North Point.	26	48
		28	48
〃	From this Cape to Yvoire,	31	45
		35	44
		36	44
		33	44
		25	47
27.	From Thonon to Morges, (great lake),	14	54
		80	43½
		123	43½
		132	43½
		123	43½
		100	43½
		35	47
		15	57
1819.			
Sept. 27.	From Morges to Ouchy,	28	50°
		13	60
		38	46
		70	44
		40	45
		21	52
28.	From Ouchy to Meillerie.	16	59
		148	43½
		161	43½
		150	43½
		145	43½
		145	43½
〃	From Meillerie to St Gingoulph.	128	43½
		118	43½
		110	43½
		109	43½
29.	From St Gingoulph to Vevay,	90	43½
		104	43½
		108	43½
		98	43½
30.	From Vevay to the Castle of Chillon.	81	43½
		59	44
		67	44
		58	44
	From Vevay to Rolle,	137	43½
		163	43½
		164	43½
		65	44
Octr. 1.	From Rolle to Yvoire,	35	46

From this Table, it appears, that at the depth of from 40 to 70 fathoms, the temperature is 44° Fahr., with the exception of the 40 fathoms near Ouchy, where it is 45°; that the temperature from 80 fathoms to the greatest depth, is invariably 43½; and that in the first 40 fathoms from the surface, the temperature varies according to circumstances, but always in such a way as to shew that the cold increases with the depth.

It deserves to be noticed, that neither the thermometer, which was encircled with polished brass, nor the lead, could be perceived at greater depths than from 3½ to 4 fathoms, though the water had the most perfect transparency.

Along with the map, I have given four sections of the Lake, in which the scale of depths is the same as that of the horizontal distances.

ART. XIX.—*Account of the celebrated Slide of Alpnach, constructed on Mount Pilatus by* M. RUPP, *Engineer**. Communicated by Professor PICTET.

IN our first Number, p. 193, we had occasion to give a brief notice of the celebrated slide of Alpnach, constructed upon Mount Pilatus, in the Canton of Underwald, by Mr John Rupp of Reutingen in Suabia; and we have particular pleasure in being able to recall the attention of our readers to a work no less interesting, from its stupendous magnitude, than from the talents and perseverance which have been exhibited in its construction.

For many centuries, the rugged flanks and the deep gorges of Mount Pilatus were covered with impenetrable forests. Lofty precipices encircled them on all sides. Even the daring hunters were scarcely able to reach them, and the inhabitants of the valley had never conceived the idea of disturbing them with the axe. These immense forests were therefore permitted to grow and to perish, without being of the least utility to man, till a foreigner, conducted into their wild recesses in the pursuit of the chamois, was struck with wonder at the sight, and directed the attention of several Swiss gentlemen to the extent and superiority of the timber. The most intelligent and skilful individuals, however, considered it quite impracticable to avail themselves of such inaccessible stores. It was not till November 1816 that M. Rupp and three Swiss gentlemen, entertaining more sanguine hopes, drew up a plan of a slide, founded on trigonometrical measurements. Having purchased a certain extent of the forests from the commune of Alpnach for 6000 crowns, they began the construction of the slide, and completed it in the spring of 1818 *.

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* This article is drawn up from a manuscript translation of a paper in Gilbert's *Annalen*, 1819, Cahier 5, made for the *Bibliotheque Universelle.*—ED.

The slide of Alpnach is formed entirely of about 25,000 large pine trees, deprived of their bark, and united together in a very ingenious manner, without the aid of iron. It occupied about 160 workmen during eighteen months, and cost nearly 100,000 francs, or L. 4250. It is about 3 leagues, or 44,000 English feet long, and terminates in the Lake of Lucerne. It has the form of a trough, about 6 feet broad, and from 3 to 6 feet deep. Its bottom is formed of three trees, the middle one of which has a groove cut out, in the direction of its length, for receiving small rills of water, which are conducted into it from various places, for the purpose of diminishing the friction. The whole of the slide is sustained by about 2000 supports, and in many places it is attached, in a very ingenious manner, to the rugged precipices of granite.

The direction of the slide is sometimes straight, and sometimes zig-zag, with an inclination of from 10° to 18°. It is often carried along the sides of hills and the flanks of precipitous rocks, and sometimes passes over their summits. Occasionally it goes under ground, and at other times it is conducted over the deep gorges by scaffoldings 120 feet in height.

The boldness which characterises this work; the sagacity displayed in all its arrangements, and the skill of the engineer, have excited the wonder of every person who has seen it. Before any step could be taken in its erection, it was necessary to cut several thousand trees to obtain a passage through the impenetrable thickets; and as the workmen advanced, men were posted at certain distances in order to point out the road for their return, and to discover, in the gorges, the places where the piles of wood had been established. M. Rupp was himself obliged, more than once, to be suspended by cords, in order to descend precipices many hundred feet high; and in the first months of the undertaking he was attacked with a violent fever, which deprived him of the power of superintending his workmen. Nothing, however, could diminish his invincible perseverance. He was carried every day to the mountain in a barrow, to direct the la-

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* These dates must be erroneous, as Mr Playfair saw the slide in operation in 1816.—Ed.

bours of the workmen, which was absolutely necessary, as he had scarcely two good carpenters among them all, the rest having been hired by accident, without any of the knowledge which such an undertaking required. M. Rupp had also to contend against the prejudices of the peasantry. He was supposed to have communion with the devil. He was charged with heresy, and every obstacle was thrown in the way of an enterprise, which they regarded as absurd and impracticable. All these difficulties, however, were surmounted, and he had at last the satisfaction of observing the trees descend from the mountain with the rapidity of lightning. The larger pines, which were about 100 feet long, and ten inches thick at their smaller extremity, ran through the space of *three leagues*, or nearly *nine miles, in two minutes and a half*, and during their descent, they appeared to be only a few feet in length. The arrangements for this part of the operation were extremely simple. From the lower end of the slide to the upper end, where the trees were introduced, workmen were posted at regular distances, and as soon as every thing was ready, the workman at the lower end of the slide cried out to the one above him "*Lachez*," (Let go.) The cry was repeated from one to another, and reached the top of the slide in *three* minutes. The workmen at the top of the slide then cried out to the one below him "*Il vient*," (It comes,) and the tree was instantly launched down the slide, preceded by the cry which was repeated from post to post. As soon as the tree had reached the bottom, and plunged into the lake, the cry of *Lachez* was repeated as before, and a new tree was launched in a similar manner. By these means a tree descended every five or six minutes, provided no accident happened to the slide, which sometimes took place, but which was instantly repaired when it did.

In order to shew the enormous force which the trees acquired from the great velocity of their descent, M. Rupp made arrangements for causing some of the trees to spring from the slide. They penetrated by their thickest extremities no less than from eighteen to twenty-four feet into the earth, and one of the trees having by accident struck against the other, it instantly cleft it through its whole length, as if it had been struck by lightning.

After the trees had descended the slide, they were collected into rafts upon the lake, and conducted to Lucerne. From thence they descended the Reuss; then the Aar to near Brugg, afterwards to Waldshut by the Rhine, then to Basle, and even to the sea when it was necessary.

In order that none of the small wood might be lost, M. Rupp established in the forest large manufactories of charcoal. He erected magazines for preserving it when manufactured, and had made arrangements for the construction of barrels for the purpose of carrying it to the market. In winter, when the slide was covered with snow, the barrels were made to descend on a kind of sledges. The wood which was not fit for being carbonised, was heaped up and burnt, and the ashes packed up and carried away during the winter.

A few days before the author of the preceding account visited the slide, an Inspector of the Navy had come for the purpose of examining the quality of the timber. He declared that he had never seen any timber that was so strong, so fine, and of such a size, and he concluded an advantageous bargain for 1000 trees.

Such is a brief account of a work undertaken and executed by a single individual, and which has excited a very high degree of interest in every part of Europe. We regret to add, that this magnificent structure no longer exists, and that scarcely a trace of it is to be seen upon the flanks of Mount Pilatus. Political circumstances having taken away the principal source of the demand for timber, and no other market having been found, the operation of cutting and transporting the trees necessarily ceased. The money, we understand, which was paid for the Forest, has been employed in building at Alpnach a church, in every respect disproportioned to the population and resources of the village *.

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* Mr Playfair's very interesting paper upon the Slide of Alpnach, will appear in the IXth Vol. of the Edinburgh Transactions, now in the press.

ART. XX.—*On certain Optical Phenomena exhibited by Mother-of-Pearl, depending on its internal structure.* By J. F. W. HERSCHEL, Esq. F. R. S. &c. Communicated by the Author.

IN repeating the experiments of Dr Brewster on mother-of-pearl, described in the *Philosophical Transactions* for 1814, Part II., I observed some new phenomena exhibited by that singular body in its action on transmitted light, depending on the internal arrangement of its molecules, and at the same time connected with a peculiarity in its superficial appearance under the microscope, which seems to have eluded his notice. When a plate of mother-of-pearl, cut parallel to the natural surface of the shell, is reduced by grinding to a thickness between $\frac{1}{70}$th and $\frac{1}{300}$th of an inch, and highly polished on both sides, (in which circumstances it is very transparent); if a distant candle be viewed through it, besides the pair of coloured images described by Dr Brewster, which have the same origin with those seen by reflection, there may be observed two large very brilliant and highly coloured nebulous masses, one on each side of the candle, and equidistant from it, which may readily be distinguished from the preceding by the following characters.

The first pair of coloured images, originating in the transferable superficial structure of the pearl, are always similar in position and colour, and complementary in brightness, to those seen by extraordinary reflection. In consequence, nothing can be more capriciously irregular than their situation, brightness, and distance from the centre. On passing various parts of the plate, with a parallel motion, between the pupil of the eye and the candle, they will be seen to shift their direction, expand, contract or disappear altogether, with every change in the point examined. This is not the case with the pair of nebulous masses now under consideration, which undergo little or no variation in any of these particulars, through whatever portion of the plate they are viewed. The axis of nebulous dispersion then, (or line joining the two nebulæ,) is parallel to itself, or nearly so, throughout the whole extent of the mother-of-pearl, and the energy of the cause producing it nearly or perfectly uniform.

These nebulous masses are usually about twice the distance of the coloured images, described by Dr Brewster, from the centre; and, except the plate be very thin, are much larger and more conspicuous, and particularly distinguished from them by the equable gradation and softening of their colours, which are those of the prismatic spectrum, the red being outermost. Their angle of deviation, or distance from the central image, increases on inclining the plate in the plane passing through them, while their brightness rapidly diminishes, the former being a minimum, and the latter a maximum, at a perpendicular incidence. This angle, as well as the shape and colour of the nebulæ, is the same, or nearly so, in all the specimens I have examined; nor does any marked variation in these particulars arise by a variation in the thickness of the plate, or by cutting it at any moderate angle with the natural surface; only, *in the latter case, the maximum of their intensity, and minimum of distance, takes place at such an angle of incidence, that the ordinary ray traverses the substance in a direction perpendicular to the natural surface of the shell*, which is also the direction of its greatest transparency. The minimum angle of deviation in the nebulous images appears, by the best measures I have been able to procure *, to be

For the extreme red, about - -	10° 29′
For the mean rays, - - -	6 59
For the extreme violet, - - -	4 16

The extraordinary images seen by reflection, and their complementary pair by transmission, are completely obliterated by surrounding the mother-of-pearl with oil, or varnishing its surfaces. This, however, is so far from impairing the nebulous masses, that it heightens them a little, by perfecting the polish; and should any doubt arise as to the identity of either pair, (which will sometimes happen), it may thus be immediately removed. From all these circumstances, compared with what Dr Brewster has demonstrated respecting the former pair of images, we might reasonably conclude that the latter are entirely unconnected with any peculiarity in the superficial structure, and I scarcely expected the application of the microscope to afford farther information, or lead to any result worth notice. My surprise, therefore, was extreme, when, on examining every polished specimen of mother-of-pearl in my possession with a powerful double microscope, I found that this extraordinary body, in addition to the irregular grooved superficial structure, so beautifully described by the above-mentioned philosopher, possesses (at least to all appearance) another of great regularity and delicacy; but, like the former, resisting every attempt to impair it by polishing the surface. It may be seen to most advantage on a thin polished specimen, in which the first set of undulations vary a good deal in direction and coarseness. When we view such a plate successively with a series of increasing magnifiers, under a double microscope, a power of 123 will barely shew, and one of 229 completely verify, the appearance of a minute system of rounded undulations, consisting, as it were, of fibres occasionally branching from each other, but never continued for any length. They are uniformly diffused over the whole surface, and, in their general direction, disposed in strait and exactly parallel lines, running from one end to the other, (See Plate III. Fig. 1.) In consequence they cross the first set of grooves at all angles, giving the whole surface much the appearance of a piece of twilled silk, or the larger waves of the sea intersected with minuter ripplings. Fig. 2. is an imperfect attempt to represent this appearance.

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* By passing a sun-beam, $\frac{1}{20}$th of an inch in diameter, through a thin plate, and measuring the images projected on a screen.

The interval between these undulated appearances is nearly the same in all the specimens I have examined. To ascertain it, twenty-five were counted in the space of an inch, in an image projected on a plane 10 inches from the eye, while the diameter of a small wire, projected on the same plane with the same power, measured 7 inches. The diameter of this wire, taken by the sphærometer, being $0{\cdot}0227^{\text{in}}$, gives 0.000129^{in}, or $\frac{1}{7700}$th of an inch for their mutual distance. To see them distinctly, a careful management of the illumination from below is necessary, and candle-light must be used.

To demonstrate the connection of these undulations, (which, whether real or only apparent, I shall for brevity, call the second set of grooves, denoting those observed by Dr Brewster by the first set), with the nebulous masses above described, I chose a plate in which the first set varied from the extreme of coarseness to that of delicacy, and were particularly irregular in their direction and curvature. In this I carefully marked, by small ink circles, several spots, numbered 1, 2, 3, 4, 5, 6, 7, which were then subjected to microscopic examination.

At No. 1 and 2, The two sets of grooves coincided in direction.

At No. 3, They made an angle rather more than 45° by the eye.

At No. 4, No grooves of the first set could be seen, but a power of 229 shewed some obscure and very irregular traces of coarse elevations and depressions. With this power, however, the second set were seen precisely as in every other part of the surface, and in the same uniform direction.

At No. 5, The first set, as they approached this point, grew smaller and smaller, requiring powers of 26. 34. 43. 123. in succession, to perceive them. With this latter power the second set just became visible; while with 229, both sets were seen crossing each other at right angles, with the most perfect regularity and distinctness, the former being about twice the breadth of the latter.

At No. 6, The direction of the first set varied a good deal, crossing the second from 45° to 60°.

At No. 7, They crossed at a small angle.

I now detached the mother-of-pearl, and by passing a small sun-beam successively through each of the marked spots, and noticing the relative situations of the two pairs of coloured images, it appeared that

At No. 1 and 2, The axes of dispersion in the first and second pair of coloured images were coincident.

At No. 3, They made an angle of 45° with each other.

At No. 4, There were no coloured images of the first pair whatever, while those of the second pair had precisely the same appearance and direction as in the other parts of the plate.

At No. 5, The axes of dispersion formed a right angle, the images of the first pair being very vivid, and separated by an unusually large interval.

At No. 6, The axes of dispersion formed an angle of 60°.

At No. 7, They were 17° inclined to each other.

In general, in different specimens I could always predict, *a priori*, the situation of the nebulous masses of the second pair, by observing with the microscope the direction of the second set of grooves, to which they are invariably at right angles; and the connection between the two phenomena is thus clearly demonstrated. Yet this connection is not, as in the case of the reflected colours, that of cause and effect. The nebulous masses, as we have seen, subsist when the grooves (if any) are obliterated by immersion in a fluid of equal refractive density. It is, therefore, in the internal structure of the pearl, *that we must look for the common cause of both appearances.* When we examine a thin plate of this substance by polarised light, the phenomena of a crystal with two axes of double refraction are observed *; the isochromatic lines being perfectly regular, and similarly disposed in all parts of the surface, and the colours, though not vivid and somewhat hazy, yet following in their proper order, and extending sometimes to 6, 7, or 8 repetitions of the same colour from either pole †. If, now, we notice the situation of the axes of no double refraction, with respect to what has above been called the axis of nebulous dispersion, we shall find, that *the latter is in all cases at right angles to the plane in which the former lie*, or to the *optic meridian* of the crystal.

The nebulous masses, then, in all probability, originate in a regular laminated structure, perpendicular to the natural surface of the shell, and uniformly pervading all the coats of which it consists. The laminæ, to agree with the above facts, must run parallel to each other, and in lines nearly straight along the whole surface, and the alternate ones at least must be regular crystals, having their optic meridians parallel to their own planes, and their optic axis (by which I mean the axis of symmetry in their spheroid of double refraction) perpendicular to the natural surface. The intermediate laminæ, if composed of the same substance, must have their axes inclined to those of the former at some determinate angle, depending probably on no very remote laws of crystallography. The grooved appearance above described, may possibly arise from an actual difference in the resistance of these two sets of laminæ to the action of the polishing particles, and therefore consist in a real difference of level; but this I much doubt, from the simple fact, that I have never been able to transfer their impression to other transparent bodies, such as melted rosin, shel-lac, balsam of Tolu, &c. though in all cases the first set of grooves, however fine, has been transferred with the utmost fidelity, and the 7700th part of an inch, though a very minute quantity to our senses, appears to me enormously too wide to oppose the free introduction of a fluid under such circumstances. It is more probable, that the appearance is a mere optical illusion, though a most complete one, arising from the difference of action of the contiguous surfaces on the light transmitted from below.

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* The systems of rings and the two axes of double refraction, were discovered by Dr Brewster, and this is the only example of their occurrence in substances of animal and vegetable origin, excepting in the case of *spermaceti*, where he also found them. See *Phil Trans.* 1814 p. 217., and 1818 p. 230.—Ed.

† Owing to the flexibility of mother-of-pearl, it is impossible to procure polished plates of any regular thickness, when below the 80th or 100th of an inch, which is the thickness most convenient for these experiments. Hence it is indispensably necessary to examine but a very minute portion of the plate at a time (as $\frac{1}{40}$th of an inch), and to pass in succession over various parts of its surface; otherwise the systems of rings, corresponding to the different thicknesses at once under examination, interfere with, and confuse one another, and might lead us to apprehend some considerable irregularity of crystallisation where none whatever exists.

The regularity of structure here supposed, is not at all incompatible with the irregular and arbitrary disposition of the grooves described by Dr Brewster. These are the intersections of the plain artificial surface with the thin coats deposited in succession by the living animal, which, though laid symmetrically on each other, like the laminæ of mica, have yet a slight degree of irregular curvature, and a small and varying inclination to the polished face. Their form and breadth is regulated by this curvature and inclination, like the level lines traced by a receding tide on a slightly inclined sea-beach, or those on the surface of a wooden board, where its concentric layers rise in succession at different angles to the surface. Indeed, the face of an ordinary deal plank, cut at some distance from the centre of the tree, however coarse the simile may appear, when smoothed by planing, and afterwards subjected to the friction of rough particles, as in a floor, is a lively and faithful representation of the surface of a polished plate of mother-of-pearl, in which the edges of the laminæ, reduced to the utmost tenuity, by the effect of their inclination to the general surface, are torn up in their direction of least resistance, by the action of the polishing particles. This is rendered perfectly evident by the microscopic examination of the surface, in different stages of its progress from the rough grinding to the most perfect polish, when the grooves, from an irregular, jagged, and deeply indented outline, will be seen to assume a greater and greater neatness of termination, till their curvature acquires that graceful and flowing character which ultimately distinguishes them. See Figs 3. 4. 2.

I must here take an opportunity to remark, that Dr Brewster's conclusion, as to the existence of a second reflecting force below that which produces the ordinary image, does not appear to me to rest on sufficient evidence. Were it indeed true, that the whole face of a polished plate of mother-of-pearl consists of elevations and depressions, with little or no intermediate plane surface, his conclusion would be irresistible; but, in all the microscopic observations I have had occasion to make, such has not appeared to me the case; the flat interval between two grooves bearing always a sensible proportion to that curvilinear depression which constitutes the groove itself, and affording a surface whose section may be represented by something like Fig. 5., where the portions *a b*, *a b*, are true planes on which the ordinary reflection may take place; and as each groove bears a very small proportion in breadth to the diameter of the pupil of the eye, the effect of the intervals *b c a*, *b c a*, is merely to abstract a certain uniform portion of light from regular reflection, and disperse it according to their own peculiar constitution and figure. This disposition is very distinctly visible in the impression of the surface taken on rosin, though less so in the pearl itself (unless in the first stages of its polishing), from the dispersion of the light in its interior, which renders microscopic observations on it peculiarly liable to illusion; while in the impression on rosin, each groove is seen with admirable distinctness, and its shape and the inclination of its sides may be clearly traced.

Besides the two nebulous masses above described, which lie parallel to the optic meridian of the pearl, two others, very faint, but exactly similar in character and colour, may be seen in thin pieces. They lie at right angles to the former, and at the same distance from the centre. It is evident, that neither these, nor the two principal nebulous images, are to be confounded with any of "the four images" which Dr Brewster describes as "seen by transmission in irregular pieces, which have the axes of extraordinary reflection of their two surfaces not coincident." Fig. 6. is a representation of the whole system of images, as seen in a good specimen.

SLOUGH, *July* 12. 1819.

XXI.—*Account of Micrometers for measuring Distances* *. By the late JAMES WATT, Esq. LL. D. F. R. S. Lond. and Edin. Member of the National Institute of France, and of the Batavian Society of Rotterdam.

ONE of the instruments which I propose to describe in this paper, was contrived about the year 1770 or 1771. I know I used it in the surveys of the Crinan and Gilp and the Tarbert intended canals, and also in the survey of the canal from Inverness to Fort William, now called the Caledonian Canal. The former survey was in 1772, and the latter in 1773, and it was in 1772 that I showed it to Mr Smeaton.

The instrument I used was a telescope, with an object-glass of twelve inches, and an eye-glass of one and a half inch focus, consequently magnifying eight times. In the focus of the eye-glass there were placed two horizontal hairs, see Plate III. Fig. 8. and one perpendicular hair. The horizontal hairs were about one-tenth of an inch distant from each other, and as strictly parallel to each other, and at right angles to the perpendicular hair, as I could make them. A rod being placed upright at twenty chains distant, or any other convenient distance, on level ground, an index, consisting of a round disk of about eight inches diameter, painted white, with a horizontal line of one inch wide, painted on its horizontal diameter with vermilion, was fixed upon the rod about one foot from the ground, and another similar index was moved up and down the rod, until, upon looking through the telescope, the two horizontal hairs covered the red stripes on the lower and upper indexes; the telescope being turned on its axis until the perpendicular hair was parallel to the rod. The indexes being thus covered by the horizontal hairs accurately, the upper index was fixed to the rod, and the distance, between the middle of the red stripes, on the two indexes, was divided upon the rod into twenty parts, representing so many chains, which, with the instrument I used, were upon the rod about four and a half inches each; and for distances, exceeding five chains, this division into equal parts was sufficiently accurate; but for shorter distances it is not strictly so. I therefore fixed a pin at every chain, and holding up the rod at each of them, made the necessary correction; and as the focus of the object-glass is also affected by the distance, it is proper to adjust the eye-glass to it at each station. The divisions on the rod being marked with the number of chains they represent, it was only necessary to send an assistant with the rod to any place the distance of which was wanted to be measured, and by signs to make him move the upper index up and down, until the two horizontal hairs covered the red stripes on the upper and lower indexes; the divisions on the rod then showed the distance, which I found could be ascertained to within less than one-hundredth part of the whole distance, and with a higher magnifying power, could be done proportionally more accurate. The rod I commonly used was twelve feet long, and consequently could measure thirty chains; but by sliding another rod upon it, so as to lengthen it, I measured greater distances, and where still greater were wanted, I stretched a tape horizontally, and turning the telescope on its axis, made the single hair parallel to it, fixing one index at the end of the tape, and sliding the other along it, until it subtended the distance between the wires. I then measured the subtended tape with the rod, and so ascertained the distance; but this expedient I rarely had recourse to, the distances I generally had occasion to measure rarely exceeding half a mile, or forty chains.

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* This and other papers were, about four years ago, communicated by their distinguished author to Dr Brewster, with permission to give them to the public in any way that he thought proper. We shall publish them exactly as they were communicated by Mr Watt; and we have no doubt that, independent of their value, as the productions of one who has written so little, and invented so much, they will be held in still higher estimation, as exhibiting the early inventions of one of the greatest mechanical geniuses of any age or nation.—ED.

It is plain that this instrument possesses the advantage of measuring all distances with equal accuracy, until the imperfection of vision at great distances interposes, as the scale on which they are measured expands with the distances, and in uneven ground it possesses more accuracy than the chain, and is very valuable in measuring distances from one hill to another, and across bays of the sea, where the chain cannot be used, which I experienced, in the survey of West Loch Tarbert, the northern shore of which is very much indented, and so rocky, that it is scarcely possible to measure a few chains in a straight line upon it.

I showed the instrument to all my friends at the time, and, among others, to Mr Smeaton, as I have mentioned, and used it publicly in my surveys, and it was consequently known to many people, though not published.

A Mr Green, in 1778, applied to the Society of Arts for a premium for the same invention, which Mr Smeaton apprized me of, and also informed the Society of my claims, in consequence of which I was desired to attend their Committee, where I informed them of what I had done, and at what time. Yet the Society thought fit to award Mr Green the premium, though his invention or use of the method was posterior to mine, I suppose because he had used an instrument of higher magnifying power, viz. Forty, and consequently had been able to measure greater distances, and, as was said, with greater accuracy. I made no further reclamation, as I perceived it was not in that court I could obtain justice; and as I dislike paper-war, I did not apply to any other, though there were people then living who could have attested my use of it.

Another Micrometer with a prism, I invented, I think, about that time; it consisted of a thin prism, with its surfaces nearly parallel, or inclined one degree or two, as in Plate III. Fig. 9. This prism was cut by a diamond into two parts, which, when they were fixed in the same plane, refracted all the rays which passed through them equally; but one of them remaining fixed, and the other moving on a centre at *a*, according to the dotted line, would refract that portion of the rays which passed through it, more than those which passed through the fixed part, and being placed in the focus of the object-glass of a telescope, two images were formed of each object, by which its diameter could be measured. An index, and divided sector of a circle, served to measure the comparative refractions.

This instrument I made with the sector and radius of wood, and gave it to Professor Anderson, of Glasgow College, and, I suppose, it is still among his apparatus, which he left to a public institution *. The Abbé Rochon afterwards published, in 1783, a description of some micrometers with prisms, but I think they were upon somewhat different principles in their construction.

The cross-hair micrometer, as described, leaving me too much in the power of my assistants, where the distances were greater than permitted me to read off the number of chains on the rod myself. I thought of another about 1772 or 1773, which consisted of a telescope with an object-glass of a long focus, say three or four feet; this was placed in a tube with a slit in one side of it, nearly as long as the focus of the telescope, and the object-glass being fitted to a short tube, which slid from end to end of the slit, could be moved backwards and forwards by means of a piece of metal fixed to the short tube, and coming out through the slit; a glass of six to nine inches focus was also fixed in the outer tube, of the nature of what is called a field-glass, and to this was added an eye-glass, with a cross hair-piece in its focus.

Now it is evident, that if the object-glass be moved nearer the field-glass, their common focus will be shortened, and the image at the cross-hairs diminished proportionally, until the glasses come into contact, when their common focus will be shorter than that of the field-glass alone; and two indexes fixed upon a rod being subtended by the cross-hair at any given distance, the same rod with its indexes being removed nearer the observer, upon sliding the object-glass nearer the eye, they may again be subtended by the cross-hairs, and a scale on the side of the tube will show the comparative distance they have been removed, and the distance of the first object being known, that of

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* I have heard, since writing this paper, that it is now at the Macfarlane Observatory at Glasgow.

the second will also be so. This scale could not, however, be a scale of equal parts, but one which could easily be laid down.

I made a rough model of this instrument at the time, but have never completed it, having been since engaged in concerns where such instruments were unnecessary. I described it, however, to several of my friends at the time, and, among others, to the late Mr Ramsden; but whether it has been thought of by any one else, or the problem published, I am ignorant.

ART. XXII.—*Account of Mr* MORTON's *Patent Slip, for hauling Vessels out of the water to be repaired, &c.* Drawn up from information communicated by the Inventor.

THERE are few of the practical inventions of the present day that are entitled to a higher rank, in point of real utility, than the slip recently invented by Mr Thomas Morton of Leith, for hauling vessels out of the water in order to be repaired. Some years ago Mr Morton conceived the idea of superseding the necessity of dry-docks by the use of a simple apparatus. He accordingly erected one in his own dock-yard at Leith; and after experiencing its benefits, and bringing it to perfection by successive improvements, he secured, by a patent, his exclusive right to the invention.

This apparatus, which he calls a *Slip*, is represented in section in Plate I. Fig. 6. where A, B, C are the sections of three railways constituting a plane, inclined at nearly the same angle as the slips generally used for building ships. This railway is placed on a sloping beach, and extends from above the reach of the tide down to low water-mark. A carriage or frame of wood, seen in section at D, E, F, G, H, runs along the iron railway upon rollers or truck-wheels, having flanges to guide them. Blocks are laid upon the middle or keel-beam E, of the carriage, to such a height, that the keel of the vessel may clear the ends of the cross-pieces D, F; and each block embraces four trucks, two on each side of the beam. The blocks seen at M and N, which slide upon the cross-pieces, are made up to correspond to the rising of the vessel's bottom. They run out to the extremity of the cross-pieces, and their ropes *r s*, (*r* belonging to the left hand blocks, and *s* to the right hand ones), crossing the carriage, are reeved through a sheave attached to the opposite cross-piece, up to the top of the rope rod. The shores S S (when any are necessary), are put into their places, turn upon a joint at T, and are secured (when the vessel is floating on) from falling outwards by a small chain.

When a ship is to be hauled ashore, the carriage, thus prepared, is let down the inclined plane, generally at low water. The chain of a powerful capstan is then attached to the carriage, and a water-staff is placed at the fore-end of the keel-beam, to mark the depth of the water, and be a guide in floating the vessel on. The vessel is then brought to the lower end of the carriage, and hauled over it, (having bow and quarter lines to steady her), till the advanced part of her keel takes the blocks between the fore-foot guides. The ends of the ropes *r s* are now taken on board from the rods R R, but kept slack, and the vessel is hauled forward, as the water flows, until the keel takes the blocks at the contracted part of the guides, which are just wide enough to receive it. Being still afloat abaft, (having been previously so trimmed), the vessel is then adjusted over the blocks abaft by a water-line. When the iron-guides *a b*, *c d*, are hauled up by their ropes *a e*, *d f*, they confine her to settle down truly. By heaving the capstan, she will soon take the blocks abaft, which is observed by the water-mark left on her bottom; she is trimmed upright, and the foremost bilge or sliding blocks hauled in tight. As she rises out of the water, each succeeding block is hauled in, but not till the weight of the vessel has settled well on her keel. The sliding-blocks are prevented from springing back, by their palls or catches falling into their racks; the shores are brought to her sides, and there secured. When thus secured, she is hauled up the inclined plane, at the rate of from 2½ to 3 feet *per* minute, by six men to every hundred tons. Being hauled up, she is shored from the ground; the keel-beam is secured from moving; and the sliding-blocks, with their cross-pieces, are in a few minutes removed, when the vessel is ready to be repaired.

The blocks being relieved of the vessel in the usual manner, the keel-beam, with the after cross-beam, will run from under her. The carriage is again put together, and another vessel can be hauled up a-stern of the former.

When a vessel is to be launched, the cross-pieces, with their blocks, are put under her, and she is instantly let into the water; —or, to launch and haul up vessels the same tide, temporary blocks are put under the bottom of the vessel to be launched, upon the cross-pieces, instead of the sliding-blocks, which are prepared as before to suit the vessel's bottom to be taken up; the vessel is launched; when she, and the temporary blocks which steadied her, float from the carriage, and the other vessel is taken on, and hauled up as formerly described.

One of the great advantages of Mr Morton's slip is, that it can be constructed in situations where it is impossible to have a dry dock; and that it can be removed from one place to another, and may even be carried on board a ship. Being above ground, the air has a free circulation; the men work with more comfort, and, in winter, they have the light much longer than within the walls of a dry dock. Time is even saved in carrying the materials for repairing the ship; and such is the facility of the whole operation, that ships can be hauled up, inspected, and even get a trifling repair, and be launched again the same tide. As the mechanical power is attached solely to the carriage, the vessel is exposed to no strain, and the process of repairing one vessel is never interrupted by hauling on another, as in dry docks.

A slip for a vessel of 300 tons can be constructed for about L. 500 or L. 600; and the expence of taking up a vessel will not exceed from twenty-five to thirty shillings.

The following Estimate, for Slips of a large size, has been communicated to us by Mr Morton:

Estimate of the Expence of a Slip capable of containing two Vessels, one of 400 *tons, and another of* 150 *tons.*

1*st*, Middle and side ways of the inclined plane of American red pine, with cast-iron railways complete, 300 feet long, at 20s. - - - L. 300 0 0

2*d*, Carriage or moveable frame, the keel and side-beams of which are American white oak, all the cross-beams of English oak, free of sap, with

sliding and keel-blocks, with its truck and axles turned, and all other iron work complete, &c.	240	0	0
3d, Chain of best Swedish iron, 230 feet, at 13s. 4d.	153	6	8
4th, Machine capstan complete, - -	65	0	0
5th, Patent right, confined to one set of railways, but may be transported to any other situation, as the whole apparatus can be stowed in little bulk [*],	200	0	0
	L. 958	6	8
Mason work, or piles for foundations, say - but this depends on the nature of the soil.	150	0	0
	L. 1108	6	8

In the preceding short account of Mr Morton's slip, our only object has been to convey to general readers some idea of its construction and advantages. Those who take a deeper interest in matters of this kind, will not fail to see the apparatus actually at work, and to examine all the details of its construction, which evince much ingenuity and mechanical skill [†].

We shall now conclude this notice, with the opinion of one of the most skilful and scientific navigators of the present day, in favour of Mr Morton's invention. " The advantage of such an apparatus," says Mr Scoresby, " in a vessel bound to the polar regions on discovery, might be very great, provided, in the place where there should prove a necessity for using it, the rise of tide should be sufficient for admitting its application, if the beach should be of a sloping nature. It could be prepared in short pieces, so as to be fitted together with screws; and though intended for sustaining the weight of a ship, would be by no means very cumbrous. Indeed, any vessel of 200 tons burden, or upwards, might easily carry it out in her hold, without materially, if at all, interfering with the room requisite for her stores. Thus a vessel having occasion to winter in Baffin's Bay or Davis' Strait, would require only the adjustment of the frame and ways, which three or four skilful mechanics might effect in a few days, before she could be hauled up on dry land quite beyond the reach of either ice or tides, where she would constitute as comfortable a dwelling as could be expected in such a country. The apparatus could even be applied where there was not a fall of tide equal to the depth of water drawn by the vessel, by the use of a small coffer-dam, sufficient only to stop out the tide at low water, until the railway should be adjusted so far down that at high water the vessel could float upon the frame while resting on the railway. Then the force of the ship's company would be amply sufficient for drawing the vessel up on land*."

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[*] The patent right is £100 when the vessel is one of 100 tons, and £150 for one of 200 tons.

[†] An account of the experiments made in the Government Dock-yards, in hauling up ships of war upon common building-slips, will be found in the *Sup. Encyc. Brit.* art, DOCKYARD.

Art. XXIII.—*Notice regarding the State of the Scottish Fisheries in August* 1819. In a Letter to the Editors, from Robert Stevenson, Esq. F. R. S. E. Engineer to the Commissioners for Northern Light-Houses.

HAVING been for many years conversant with the navigation of the Scottish seas, I have, prior to the war with Holland, seen fleets of Dutch busses engaged in the herring-fishery off the northern parts of our coast. For a long time past, however, these industrious fishermen had not ventured to approach these shores; and they are now only beginning to re-appear.

In the early part of August last, while sailing along the shores of Kincardineshire, about ten miles off Dunottar Castle, the watch upon deck, at midnight, called out "Lights a-head." Upon a nearer approach, these lights were found to belong to a small fleet of Dutch fishermen employed in the deep-sea fishing, each vessel having a lantern at her mast-head. What success these plodding people had met with, our crew had no opportunity of inquiring; but upon arriving the next morning at Fraserburgh, the great fishing station on the coast of Aberdeen, we found that about 120 boats, containing five men each, had commenced the fishing-season here six weeks before, and had that night caught no less than about 1500 barrels of herrings, which in a general way, when there is a demand for fish, may be valued at L. 1 Sterling *per* barrel to the fishermen, and may be regarded as adding to the wealth of the country perhaps not less than L. 3000. In coasting along between Fraserburgh and the Orkney Islands, another fleet of Dutch fishermen was seen at a distance. The harbour and bay of Wick were crowded with fishing boats and busses of all descriptions, collected from the Frith of Forth and southward even as far as Yarmouth and Lowestoffe. The Caithness fishing was said to have been pretty successful, though not equal to what it has been in former years.

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* Scoresby's *Account of the Arctic Regions*, vol. i. p. 32, now in the press.

In the Orkney and Shetland islands, one would naturally look for extensive fishing establishments, both in herrings, and what are termed White Fish, (cod, ling and tusk); but it is a curious fact, that while the Dutch have long come from their own coast to these islands to fish herrings, it is only within a very few years that the people of Orkney, chiefly by the spirited and praise-worthy exertions of Samuel Laing, Esq. have given any attention to this important source of wealth. It has long been a practice with the great fishmongers of London to send their *welled* smacks to fish for cod, and to purchase lobsters, around the Orkney islands; and both are carried alive to the London market. This trade has done much good to these islands, and has brought a great deal of money to them; but still it is of a more circumscribed nature, and is less calculated to swell the national wealth, than the herring and white fishery in general.

Hitherto the industry of the Orcadians has been chiefly directed to farming pursuits; while the Shetlanders have been almost exclusively occupied in the cod, ling and tusk fishing. It is doubtful, indeed, if, up to this period, there be a single boat belonging to the Shetland isles, which is completely equipped for the herring fishery. But here, again, another fleet of Dutch doggers was seen collecting in numbers off these islands, which is considered a rich harvest in Holland. So systematically do the Dutch pursue the fishing business upon our coasts, that their fleet of Busses is accompanied by an Hospital-ship. This vessel we now found at anchor in Lerwick roads, and were informed that she paid weekly visits to the fleet, to supply medicines, and to receive any of the people falling sick, or meeting with any accident.

Though Shetland is certainly not so much an agricultural country as Orkney, yet it may be hoped that the encouragement judiciously held out by the Highland Society, for the production of green crops in Shetland, may eventually have the effect of teaching these insular farmers the practicability of providing fodder for their cattle in the spring of the year. For ages past this has been a great desideratum. The command of a month or six weeks fodder, would enable the proprietors of that country to stock many of their fine verdant isles with cattle, and to employ their hardy tenantry more exclusively in the different branches of the fishery.

It is well known, that, next to the Newfoundland Banks, those of Shetland are the most productive in ling, cod, tusk, and other white fish; and by the recent discovery of a bank, trending many leagues to the south-westward, the British merchants have made a vast accession to their fishing-grounds. In the small picturesque Bay of Scalloway, and in some of the other bays and voes on the western side of the Mainland of Shetland, the fishing upon this new bank, (which I humbly presume to term the REGENT FISHING-BANK, a name at once calculated to mark the period of its discovery, and pay a proper compliment to the Prince,) has been pursued with great success. Here small sloops, of from 15 to 25 tons burden, and manned with eight persons, have been employed. In the beginning of August they had this summer fished for twelve weeks, generally returning home with their fish once a-week. On an average, these vessels had caught 1000 fine cod-fish a-week, of which, about 600 in a dried state go to the ton, and these they would have gladly sold at about L. 15 *per* ton. So numerous are the fish upon the Regent Fishing Bank, that a French vessel, belonging, it is believed, to St Maloes, had sailed with her second cargo of fish this season; and though the fishermen did not mention this under any apprehension, as though there were danger of the fish becoming scarce, yet they seemed to regret the circumstance, on account of their market being thus pre-occupied *.

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* See a farther account of this fishing bank by Dr Hibbert, in this Number of our Journal, p. 138.—ED.

Here, and at Orkney, we had the pleasure to see many ships arriving from the whale-fishing, and parting with a certain proportion of their crews. To such an extent, indeed, are the crews of the whalers made up from these islands, that it is calculated that not less than L. 15,000 in cash are annually brought into the islands by this means. With propriety, therefore, may the whale-fishery be regarded as one of the most productive sources of national wealth connected with the British Fisheries.

From the Orkney and Shetland islands our course was directed to the westward. A considerable salmon-fishing seems to be carried on in the mouths of the rivers of Lord Reay's Country in Sutherlandshire: the fish are carried from this to Aberdeen, and from thence in regular trading smacks to London. We heard little more of any kind of fishing till we reached the Herris Isles. There, and throughout the numerous lochs and fishing stations on the Mainland, in the districts of Gairloch, Applecross, Lochalsh, Glenelg, Moidart, Knoidart, Ardnamurchan, Mull, Lorn and Kintyre, we understood that there was a general lamentation for the disappearance of herrings, which in former times used to crowd into lochs which they seem now to have in some measure deserted. This the fishermen suppose to be owing to the *Schools* being broken and divided about the Shetland and Orkney Islands; and they remark, that, by some unaccountable change in the habits of the fish, the greatest number now take the east coast of Great Britain. This is the more to be regretted, that in Sky, the Lewis, Harris, and Uist islands, the inhabitants have of late years turned their attention much to the fishing. Indeed this has followed as a matter of necessity, from the general practice of converting the numerous small arable farms, which were perhaps neither very useful to the tenants, nor profitable to the laird, into great sheep-walks; so that the inhabitants are now more generally assembled upon the coast. The large sums expended in the construction of the Caledonian Canal, have either directly or indirectly become a source of wealth to these people: they have been enabled to furnish themselves with boats and fishing tackle, and for one fishing-boat, which was formerly seen in the Hebrides only twenty years ago, it may be safely affirmed that ten are to be met with now. If the same spirit shall continue to be manifested, in spite of all the objections which have been urged against the salt laws, and the depopulating effects of emigration, the British Fisheries in these islands, and along this coast, with a little encouragement, will be wonderfully extended, and we shall ere long see the Highlands and Islands of Scotland in that state to which they are peculiarly adapted, and in which alone their continued prosperity is to be looked for, viz. When their valleys, muirs and mountains are covered with flocks, and the people are found in small villages on the shores.

Art. XXIV.—*An Account of a New Method of Uniting Bee-Hives.* Communicated by the Reverend Andrew Jameson, Member of the Wernerian Society.

When a hive is too weak to stand over winter, or when it is wished to deprive the bees of their honey, without suffocating them, it is now the general practice to unite the hives, in either of these situations. The method of uniting bee-hives, as practised by M. Huish, except in the hands of a very experienced apiarian, is attended with very considerable risk to the lives of the bees; whilst Bonnar's method is not unfrequently attended by the destruction of a considerable proportion of the community. Feeling the want of some safe and effectual mode of uniting hives, particularly when the honey season advanced, I was induced to examine into the practice in this neighbourhood, and found a way of performing this operation of thirty years standing, of which, however, no public notice had ever been given. This manner of uniting hives, is the invention of the Reverend Richard Paxton, Minister of Tundergarth, and his thirty years experience, on a very large scale, should give great weight to the invention.

Mr Paxton's method of uniting hives is this:—An empty hive being procured, is inverted on the hive from which it is wished to dislodge the bees, either to take their honey, or to unite them with another hive. Betwixt the two hives thus connected, a small piece of wood is so placed, as to keep these two hives about an inch apart on *one side*. The reason of placing this stick across the mouths, and between the two hives, is to prevent the bees, after being driven up the one side of the hive, descending (which they would do) by the other to the hive from whence they were dislodged. The hives being in the situation now described, the operator strikes on the under hive, (taking care not to strike so strong as to hurt the combs), till the bees, being terrified by the noise, take refuge in the upper hive. A quantity of small beer must be made milk-warm, and as much soft sugar melted in it as will make a thin gruel. A bunch of feathers, or brush, must also be ready. The operator now gently lifts the hive containing the dislodged bees: his assistant also is ready to lift up the hive with which these are to be united. The hive which is to receive the new colony is turned with its mouth upwards, when a person standing ready sprinkles as quick as possible the bees as they show themselves with the liquor already described. When he thinks all are pretty well drenched, he stops. The same operation having been performed on the other hive, that is, the hive which was dislodged from their own work, these bees are emptied into the hive destined to receive the colony as quick as possible, and swept with a bunch of feathers into the interstices between the combs. The hive is instantly reverted, and placed on the stand.

The operation is best performed in the evening. In a few hours after the union, all will be quiet. Next day, you may perhaps see a few skirmishes, owing to the sprinkling liquor having missed some of them; but very few will suffer death. This year I do not think I lost threescore of bees by the operation. Four quarts of small beer, with 1½ lb. of common soft sugar, should do for the uniting of two common sized hives.

In this method of uniting hives, there is no danger of drowning the insects, as there is in uniting them by M. Huish's manner, or creating a bloody and exterminating civil war, the general consequence of Mr Bonnar's plan.

The explanation of the principle may be left to naturalists. It would appear, that bees judge very much by the smell, and that all those scented by the small-beer and sugar are thus induced to regard each other as friends and associates.

St Mungo,
November 1819.

Art. XXV.—*Account of an Improved Catoptrical Microscope, by* Professor Amici *of Modena.* Translated from Gilbert's *Annalen* *.

Microscopes constructed on catoptrical principles, have been known since the time of Newton; but in consequence of their imperfection, and the great improvements made upon the dioptrical instruments, they have been, of late, almost entirely neglected.

Some years ago, an eminent natural philosopher, Professor Amici of Modena, constructed a very excellent catoptrical microscope, in which he seems to have avoided the imperfections to which the instruments formerly constructed upon the same principle were liable, and to have combined several advantages which are not possessed by the best dioptrical microscopes now in use. The ingenious inventor has lately published a minute description of this improved instrument, in a memoir inserted in the 18th volume of the Transactions of the Italian Society.

The body of this microscope consists of a horizontal brass tube, 12 inches in length, and $1\frac{1}{10}$th in diameter. At one end of the tube is placed a concave speculum of metal, whose axis coincides with that of the tube, and whose superficies is elliptical, and so calculated, that of the two foci, the one falls at the distance of $2\frac{6}{10}$th, and the other at 12 inches from its centre. A small arm within the tube, carries a small plain mirror of metal of an oval form, placed at the distance of $1\frac{6}{10}$ inches from the former, opposite to it in an oblique direction, and supported by an oblique section of a metal cylinder $\frac{5}{10}$th of an inch in diameter. The centre of the polished surface of this mirror coincides with the axis of the concave mirror, which is situated at the distance of $1\frac{5}{10}$ inches from the centre of the other.

This plain mirror is so placed, that, while it receives the image of the object (which is placed on a moveable object-bearer attached to the pillar below it) by means of a small aperture in the under part of the body of the tube, it throws it towards the concave mirror, in which it may be examined by the eye of the observer, applied to the opposite end of the tube, through a greater or smaller number of magnifying eye-glasses, which may be fitted to it.

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* In vol. i. p. 214. we have given a notice respecting this microscope, communicated to us by His Royal Highness the Archduke Maximilian, who, we understand, has recently presented one of the instruments to the Imperial Cabinet of Natural History at Vienna.—Ed.

The internal diameter of the tube, which regulates that of the large mirror, may be $1\frac{1}{10}$ inches, and the thickness of the surrounding metal about $\frac{1}{20}$th. Upon this construction, the object to be examined may always be at the distance of half an inch from the edge of the tube, and consequently be very well lighted on every side,—transparent objects from below, by means of a common illuminating mirror, fitted to the pillar, and moveable,—and opaque bodies from above, either by the natural light falling directly in, or by concentrating an artificial light, by means of a convex glass fitted to the object-bearer,—or still better, by means of a pierced mirror of metal, which is fitted to the tube below, over the object, so as to be brought more or less near to it. The large illuminating mirror below should be concave, having a diameter of three inches, and a focal distance of 2.5 at the utmost.

The effects of the two last-mentioned mirrors may be reciprocally combined, by means of a common corresponding adaptation,—by receiving and reflecting the rays of light, so as to produce the highest degree of intensity of light, and the most perfect illumination of the object on all sides, both as a whole, and in its different parts,—an advantage, indeed, which may be attained in dioptrical instruments, by similar means.

The inventor considers the proportions above given as best adapted for the convenient use of the instrument, in order to preserve, along with a high degree of effect, and even the highest degree of magnifying power, a moderate distance of the object from the microscope, viz. half an inch, which not only allows the most simple and perfect illumination from above, but also admits of our examining objects of a considerable size entire, without separating the parts, and also small animals alive.

A common dioptrical microscope, whose object-glass has a focal distance of six lines, would correspond with this state of the object, and consequently admit of similar advantages, but with a much diminished magnifying power, of about 1500 or 2000 in the area.

Professor Amici has accordingly compared the best English microscopes of Adams and Dollond with his own, and, upon a comparative examination of the same objects, he maintains that his instrument shews the object more clearly and distinctly, even when magnified in the same degree. The Professor had no opportunity of making experiments with the microscope of De la Barre, and those made at Benedictbeuern by Utzschneider and Fraunhofer; but he thinks himself justified in concluding, that his own admits of a far greater degree of magnifying power than the latter, as he perceives that their largest microscope does not magnify the objects above 22,500 times in the area, while his goes the length of a million. He has also endeavoured to shew, by a mathematical calculation, that such a high degree of magnifying power cannot be attained in a dioptrical instrument.

The following, according to Amici, are the advantages of his microscope.

1. The observer has the convenience of being able to examine the object in a horizontal position, while, in those constructed on the dioptrical principle, the object is examined in a vertical position, that is, from above. The observer, therefore, may be seated, has no occasion to bend his head, and can examine objects more conveniently, or for a longer time, than with a large dioptrical instrument on the common construction.

2. The different degrees of magnifying power can be easily and speedily applied and changed, nothing more being necessary for this purpose than to change the eye-glass, without varying the position or distance of the object, so that it may be examined with great rapidity in all different degrees of magnitude, without the least variation of the point of view; while in the dioptrical instruments, it is necessary not only to change the object-glass, but also the visual distance, which not only occasions loss of time, but very seldom admits of the object being again seen in the same position, and in the same point of view.

3. As in this new instrument the object always remains in the same position, and is kept constantly at the distance of half an inch from the body of the microscope, it consequently admits of our examining objects immersed in fluids, and animals swimming, and that nearly at an equal depth, and in every degree of magnitude. With dioptrical instruments, on the other hand, this is

quite impossible, on account of the shortness of the focal distance in the highest degrees of magnifying power, as the object-lens must be brought so near the object as almost to come in contact with the fluid.*

4. The light may be brought to bear upon all sides, and in all directions, even by means of a lamp or a taper, as the flame can be brought very near the illuminating mirror, without being troublesome to the observer.

5. As metallic specula do not disperse the light, and consequently produce no colours, the objects appear of their natural colour.

6. The diameter of the concave mirror being so large, compared with its focal distance, we may expect so much more distinctness.

7. As the distinctness of the image produced by reflection is greater than that produced by refraction, the degree of magnifying power may be carried much higher.

We must not omit to mention, that Professor Amici has contrived, by a very ingenious arrangement, to convert his microscope into a species of *camera lucida*, in order to enable the observer conveniently and very exactly to delineate the object, in any degree of magnitude, at pleasure. This circumstance undoubtedly enhances the value of the invention.

ART. XXVI.—*Account of the Discovery of the Shetland Cod-Bank in the Summer of* 1818. In a Communication from SAMUEL HIBBERT, M. D. M. W. S., &c.

THE certain knowledge that a very extensive Cod-bank existed to the west of the Shetland Islands, was the discovery of the summer of 1818, and it will form an important epoch in the annals of the British fishery. The visit which I paid to Shetland last year, for the purpose of examining its geology, comprised a period, when, from a mere suspicion of the existence of the bank, its reality was as a point of fact established. Aware of the importance of the discovery in a national point of view, I omitted no opportunity afforded me to procure every information in my power, with regard to its situation, extent, and productiveness; and a very brief account of the result of my inquiry was communicated to the public in January 1818. The testimonies which I obtained from various individuals, only disagreed on subordinate points; but these I have been enabled to correct and enlarge by the experience of another unprecedented season of successful fishing conducted on the new bank.

The cod-bank of Shetland is described by the fishermen as lying from twenty-five to thirty miles west of Foula. That its extent is very great, all who have fished upon it agree. The information politely given me by Mr Sheriff Duncan of Lerwick *, fully corroborates the previous statement I had made on the subject last year. " The fishing vessels," says this gentleman, " spread themselves so widely over the bank, that it seldom happens that more than two or three are in sight of each other at the same time, yet they have never reached its utmost boundary." I shall, however, communicate what is known of its extent, from the experience of a former season. The bank appears to commence near the cluster of Islands bearing the name of Orkney: it is said to lie into the land about sixteen miles. The fishermen refer to the west of Westray as its origin; and from thence it is continued in a direction nearly N. by W. having been variously entered upon in steering from the east, even as far distant as about twenty miles north-west of Shetland. If this information be correct, it would give to what is known of the extent of the bank, a distance of about 140 miles.

Respecting the depth of water on the bank, I reported last year, that it was from 28 to 47 fathoms: the information recently given me, assigns to it a depth of from 40 to 50 fathoms. This discrepance of opinion, which is not of material consequence, probably arises from the difference of observations taken near the origin of the bank at Orkney, or to the west of Foula, where its form becomes more definite. Its breadth has been reported to me as varying from 18 to 45 miles; here also I have met with some little difference of opinion, which naturally arises from an indecision respecting the exact depth to which its boundaries or shelving sides may be referred, and

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* I am indebted to Mr Duncan, through the medium of my friend, Mr Ross, late of Lerwick, for much information relating to the success of this year's fishery.

which can only be rectified by extensive soundings. The surface of the bank is described as in some places rocky, and in others sandy, and as covered by buckies, mussels and razor-fish *.

After recounting what is known of the bank, it may be proper to mention the speculations which have been made regarding its extent. That it is continuous with a cod-bank near the Faroe Islands, is contended for, not only from the general direction of the Shetland Bank, which bears towards that very northerly and remote group of islands, but also from a similarity of character in the fish caught at each place. The cod of both Shetland and Faroe have been described to me by a gentleman familiar with the fish, as grey backed, spotted with black, and tinged with a ring, which is of a brownish colour, inclining to grey. This continuation, then, the existence of which is very problematical, may perhaps take place, rather by a series of distinct banks in a given direction, than by one that is uninterrupted.

In connection with the history of the bank, it may not be uninteresting previously to enquire if it was really known to those nations who cannot be accused of a supineness in the prosecution of their fisheries, and my inquiries will be principally directed to the Dutch, who for nearly three centuries have been the principal fishers frequenting the coast of Shetland.

In order to understand the history of the Shetland fishery, we must distinguish between those nations who prosecuted it through the medium of the inhabitants of Shetland, and those who, avoiding such an intercourse, obtained the lucrative object of their visits by an equipment which rendered them independent of the people whose coasts they visited. The merchants who prosecuted the Shetland fishery, through the medium of the natives of the place, were from Hamburgh, Lubeck, Bremen, and Denmark. They occupied booths or shops in the country, and trafficked with the Shetlanders chiefly for ling. This fish is caught in deep water, at a distance of thirty miles from land †. For this purpose light six-oared boats are at present

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* A beautiful species of infundibuliform sponge obtained from the bank, and kindly forwarded to me by Mr Henderson of Papa Stour, is attached to a large fragment of quartz, which is probably the rock of which the bank is composed.

† Along with ling is taken the torsk-fish or tusk.

employed, 18 feet in keel, and 6 in beam, the adventurous crews of which carry each a stretch of lines amounting to 6000 fathoms, with 1200 attached hooks. The German and Danish merchants, who had almost exclusively conducted the Shetland ling fisheries for nearly two centuries, left these shores in consequence of the bounties granted for the exportation of fish from Great Britain, agreeably to the acts of the years 1705 and 1714. To these visitors succeeded occasional companies of Scotch and English merchants, who were actuated by the new bounty; but eventually the fishery devolved to the Shetland landholders, whose policy it was to parcel out occupations to a number of individuals, involving at the same time, in the conditions of their holdings, the obligation to supply them at a stipulated rate with all the ling they caught during the customary summer season. The fish, when dried, were chiefly exported to the shores of the Mediterranean, and to Ireland.

The second description of visitors to Shetland, for the purpose of prosecuting the fishery of the place, comprehended, as I stated, that people who, avoiding an intercourse with the natives of the shores which they rifled, obtained the lucrative object of their visits by an independent equipment: I here allude to the Dutch nation. An inquiry into the nature of their visits to Shetland will involve in it the question, whether the cod-bank, first generally made known to this country in the year 1818, was or was not previously resorted to by this reserved nation, who concealed from the rest of the world the fact of its existence, or whether the knowledge of it, if really acquired by us, scarcely became an object of remembrance, owing to our proverbial supineness in every thing relating to the advancement of the British fisheries? The independent system of the Hollanders, and their little communication with the natives of the country, the policy of which is obvious, is alluded to by Brand, in his Tour to Shetland in the year 1712. "The Dutch," he remarks, "*cannot be said so properly to trade with the country, as to fish upon their coasts.*" In fact, they only purchased fresh victuals from the natives, and a few stockings.

The Dutch fishery is first particularly noticed by Captain Smith, who, in 1633, by order of the Earl of Pembroke, and the British Fishery Company of London, visited the islands of Shetland. He saw 1500 sail of busses, of 80 tons each, taking herring on the coast of Shetland, with twenty rafters or ships of war, carrying 20 guns each, as convoys. But the confirmation which he adds to this narrative, relating to a distinct establishment which the Dutch possessed, for the purpose of prosecuting the cod fishery, is so remarkable, and is so involved in the question of the importance of this new accession to our national resources, that I shall give Captain Smith's account in his own words. Besides 1500 sail of herring busses and 20 wafters, "there were also," he adds, "a small fleet of dogger-boats, which were of the burden of 60 tun and upward, which did fish only with hooks and lines for ling and cod. Many of these boats and busses came into several havens or sounds, to fit and trim themselves. *One thing was observable, that within eight or ten days after the dogger-boats went to sea, they came into the sound again so full laden as they could swim.* The certain number of dogger-boats I could not learn, but the general report was about 400 *." Upon the narrative of Captain Smith, I have certain remarks to make. The dogger-boats are stated in very general terms to fish for ling and cod; but which of those fish was the leading object of their pursuit, our early narrator does not on this occasion inform us. It is well known, that the mode of prosecuting the white fishery, inasmuch as it has for its leading object the taking of cod or ling, differs in certain essential points. The ling is sought for in deep water; the cod, on the contrary, is taken in the greatest quantity upon banks or on shoals. For the taking of ling, long lines, baited with many hundred hooks, are allowed to remain in deep water all night. Hence the intent of employing open boats, that may not be driven to a distance from their lines. Cod, on the contrary, is caught by hand-lines, baited with single hooks, which are dropt into the water from the sides and stern of decked vessels.

It is possible to conceive, that the Dutch, in prosecuting the ling-fishery, by means of their doggers, had recourse to the expedient of a drove sail, which, by restraining the motion of their vessels, prevented them from being driven far from the lines which they had laid. But it may be remarked, that whenever the Dutch fleet of doggers is described, with regard to its particular object, it is distinctly stated to be intended *for the cod-fish-*

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* Smith's England's Improvement revised.

ery. Thus in Sir Robert Sibbald's description of Shetland, bearing the date of 1711, the following passage occurs: " But the greatest advantages Shetland hath is from the fishing of herring *and cod,* which abounds so, that great fleets of the Hollanders come there, and begin to take herring upon St John's Day, with their busses. But," the author adds, " they at the same time employ hundreds of doggers for *taking of cod.*"

From what has been advanced, I am disposed to believe, that the ancient importance of the Dutch cod-fishery of Shetland has been much underrated, and overlooked, by confounding it with a fishery of a different kind; that of ling being for the most part conducted through the medium of the natives of Shetland.

The second remark which I have to make upon Captain Smith's early narration, refers to the success of the Dutch doggers. It may be observed, that, previous to the cod-bank being found out in the year 1818, the fishery, which was conducted round every part of the Shetland coast, was highly desultory and uncertain; and it rarely happened that vessels of only 10 to 30 tons, after being employed a week in fishing, returned to their several harbours, like the Dutch doggers described by Smith, " so full laden as they could swim." But Captain Smith tells us, that vessels capable of holding a much greater quantity of fish, and amounting to even 60 tons, came into the harbours, after an eight days cruise, full laden. For the reasons thus given, I am strongly inclined to suspect that the bank was, two centuries ago, well known to the Dutch, and that the knowledge of it was either carefully withheld from this nation in particular, or, which is more probable, regarded by us with such an indifference, that when the Dutch left our shores, owing to the interruption they experienced in our wars with them, it was soon forgotten that such a bank existed. In support of the latter opinion, a gentleman in Shetland last year informed me, that he had a distinct recollection of formerly seeing in an old Dutch chart the notice of a bank to the west of Foula, corresponding to the observations made in the year 1818.

For nearly a century and a half after Captain Smith's visit, we find that the Dutch still continued to prosecute the cod-fishing on the coast of Shetland. In a MS. tour of the late Reverend George Low, in my possession, made through Shetland in the year 1778, it appears that this gentleman was present when Bressay Sound was filled with Dutch busses preparing to set out for the herring-fishery. After describing, in a very particular manner, the arrangements and economy of this fleet, he adds, "Besides the herring-busses, the Dutch send out many doggers on the cod-fishing. These are going and coming from early spring through the whole summer. Each dogger has ten men and two boys, the half of whom sleep while the other are employed in fishing."

The evidence yet to be given respecting the cod-fishery of Shetland, comprises the most recent circumstances relating to the Bank, subsequently to the departure of the Dutch from our shores, and refers to visits which were made to the Bank by the British: these were accidental. It appears from Mr Low, in his Fauna Orcadensis, that a bank lying to the north-west of the Burgh of Birsay in Orkney, was well known in these islands; but, that it was a bank extending to the west of Foula, and even much farther north, was a circumstance to which the islanders seem to have been perfect strangers. "The cod-fish," he remarks, "is found in swarms on the banks all round the coasts, but is very little sought after. Of old this was not the case. Merchants from the south had their factors here, and many fish were yearly made and transported from these isles. Now all is sunk in indolence and sloth."

Additional evidence relating to an accidental visit to the bank has been given me by Mr Duncan, the intelligent gentleman whose communications I have before acknowledged. "I recollect," he informs me, "that a vessel came into Bressay Sound several years ago, with her decks filled with cod. I was told by the master of the vessel, that they had been caught to the northward of the Orkneys, during two or three hours of a calm. The master must therefore have been upon the bank when he fell in with the fish, since it stretches round the northward of these islands."

The next evidence I shall offer on the subject of the bank, with reference to an historical order, will appear in an extract I shall make from an interesting Tour through Orkney and Shetland, made by Mr Neill of this city during the summer of 1804. It was not likely that an accidental and remarkably successful experiment, determining the productiveness of the Orkney fishing-ground, would escape the notice of this gentleman, whose ardour and superior information on all subjects connected with natural history is well known, and it is not without very great reason that he feels some impatience at the apathy with which we have long regarded our northerly sources of wealth. It may be premised, that any observations which Mr Neill might make regarding the fishery off the north of Orkney, would apply to the southerly commencement of the cod-bank of Shetland. "We weighed anchor," says that gentleman, "in the afternoon, and got under way with a gentle breeze. The sailors, being provided with strong lines, we here lay to, and fished for cod and haddock. So abundant were these kinds of fish in this place, that in an hour our deck was strewed with about fifty fine firm cod-fish, besides some haddocks of a large size. This was not two miles distant from Papa Westray; *yet we saw no boat engaged in this rich fishery!* How supine is such conduct," (p. 67.)

I am now glad to find, that the too well-founded charge of supineness, is for the first time likely to be totally removed, by the exertions of the gentlemen of Shetland, which have been made this season, and which are in the progress of being extended to an unprecedented degree.

It is, I believe, about ten or twelve years, since a few vessels, from six to thirty-five tons burthen, and carrying from six to eight hands, first prosecuted a desultory and uncertain fishing for cod off the coasts of Shetland. They seldom went farther to look for fish than the immediate neighbourhood of Foula and Fair Isle; and their success in general was very limited. To some of the vessels thus employed the discovery of the bank is due. The first knowledge of its existence is contended for by three or more parties; but the great probability is, that it was simultaneous, since the same cause, which was the uncommon fine spring of 1818, caused almost every vessel to seek for fish, at a more than usual distance from the coasts of Shetland, and finding a very abundant supply off the north of Orkney, in the vicinity of the place which attracted Mr Neill's attention, they fell in with the track of the cod-bank. The priority of the discovery is, however, most in favour of the vessels of John Ross, Esq. of Weesdale, who are said to have fished upon the bank late in the autumn of 1817, and so aware were the crew of the advantage of the fishing-ground, that it became their constant station during the whole of the ensuing summer of 1818. When I visited Mr Ross on the conclusion of the fishing last year, so unexpected was the success which he experienced on the bank, that his preparations to cure the great quantity of fish taken not being sufficiently extensive, they were suffering from the want of beaches upon which they might be dried. I believe also, that a vessel from Scalloway shared by six men, claims the merit of the discovery.

Lastly, I am informed by Mr Duncan, from the authority of another party, "That the bank was not discovered, so as to excite attention, until last year, that a small fishing-vessel belonging to Lerwick, which had been forced off her usual fishing-ground by unfavourable weather, fell in with it by accident." I can certainly add, that a little before leaving Shetland, early in the autumn of last year, the knowledge of the bank was far from being general; and an excellent opportunity was afforded me in the island of Papa Stour, of witnessing, in the contrasted success of two vessels engaged in the cod-fishery, a decided proof of the importance of the discovery. The skipper of one of the vessels obstinately persisted in looking for fish in the places to which other vessels had been previously accustomed to resort. The other skipper, who, having formerly belonged to the Royal Navy, was accustomed to adventure, boldly steered at a considerable distance from land to the fishing-bank, where he saw other vessels so profitably engaged. The consequent difference of success in each vessel was remarkable. Whilst sympathising in the disappointment which the proprietor of the two vessels experienced in the empty hatches of the first sloop which came into the harbour, the subsequent entrance of the other vessel, rich with the product of the new bank, amply compensated for the failure of the less adventurous crew.

These are the circumstances I have to offer relating to the history of the bank, connected with its complete discovery. I have now to add, that its productiveness is established beyond a doubt by the experience of two seasons. One boat last year, which fished nearly the whole season on the bank, or contiguously to it, took 11,000 fish, equal to 39 ton of wet fish, or 15 ton of dried fish. I was indeed informed, that upon one occasion, a vessel with six hands took, in a single tide or day, 1200 fish. The general result of the fishery, however, of last year, could not fairly represent the productiveness of the bank, since the vessels which constantly resorted thither were comparatively few. Notwithstanding, thirteen vessels, from 10 to 35 tons burden, and having from six to eight hands each, fished, upon an average of each, 12 tons of dried fish ; when, in previous years, the average was 3 or 4 tons less. During this year, however, a fair trial of the bank was made. The fishing season commenced in May and terminated in August. The number of vessels on the bank were increased from thirteen to twenty-five, and were of various sizes, from 10 to 60 tons burden, and manned with from six to 12 hands each, boys included. The average quantity of cod taken, was much greater than that of previous years, being not less than 15 tons of dried fish for each vessel, when, prior to the year 1818, a sloop often took only 6 or 7 tons, and never at the utmost exceeded in this respect 12 tons. Some vessels, however, this year are understood to hav eobtained from 20 to 25 tons each.

Having now put on record every circumstance relating to the recent discovery of the cod-bank, connecting, at the same time, this information with what is historically known of the cod fishing of the Dutch, nothing more remains for me than to state, as concisely as possible, the obstacles, as well as encouragements, which appear to be incidental to the discovery.

The obstacles incidental to the present mode of conducting the fishery, chiefly refer to the subject of proper bait. That which is used by the Shetland fishermen consists of the common mussel, the Mytilus modiolus or *yoags*, a large species of whelk, and other shell-fish common to almost every northern coast. These are found very abundantly in the numerous voes and inlets of the country. Now, the vessels depending for a supply of bait upon the coast are often obliged, when run short, to quit the fishing-bank with all expedition : they thus encounter a considerable loss. When the Dutch prosecuted the Shetland cod-fishery, they depended for bait, in the first instance, upon a supply of lampreys, which they brought with them from their own coasts, and afterwards upon the nets which were intended for the same purpose to take herring. "To hinder the too rapid motion of the vessel," says Mr Low, "which would prevent their lines from taking the bottom, each has what they call a drove-sail, or one which hangs under water, and effectually stops her way. They can then pursue their business at leisure."

With regard to the improvement of which the fishery is internally susceptible, it has been suggested, that in case of a weak demand for dried fish, the preparation of what is called *mud fish* may be expedient. This preparation agrees with the Dutch method when they fished off Shetland. Soon after a cod was caught, it was split and laid in salt. When thus brought into the market, a barrel of cod fish, in May 1778, fetched thirty to forty guilders, when one of herrings would not bring six.

It is evident, with regard to dried cod, that the fish prepared in Shetland, will ever maintain its pre-eminence over the cod of other places. The Newfoundland fishermen are described as exposing their fish, after it has been salted, on standing flakes, made by a slight wattle, and supported by poles often 20 feet from the ground. But the humidity is not near so well extracted from the fish as when, according to the Shetland method, they are carefully laid out upon dry beaches, the stones of which have been, during winter, exposed to the abrading action of the ocean, and are thus cleared from vegetable and animal matter.

I am informed that the fishing season for cod might be successfully prolonged. It regularly commences in May, and ends in August; but Mr Duncan remarks, that stout vessels might be employed the year round, as the cod is to be taken at all seasons.

It has been suggested to me, that a serious injury may arise to the cod-fishery of Shetland, if foreign nations are suffered to fish upon the bank, and thus be allowed to enter into a competition with us in continental markets; also, that the bank can never become an object of much importance in a national point of view, unless an adequate bounty be paid on the quantity of fish caught, whilst no restrictions are imposed in allusion to any market to which it may be sent. The merits of these questions may be safely confided to the wisdom of the Legislature.

I have now brought my remarks on the new cod-bank to a conclusion; and in selecting the statements laid before the public, although I have endeavoured to exercise every due caution, it will be evident that, in estimating the true value of the discovery, it ought to bear reference to a complete and scientific survey of the whole bank *. Still it is impossible, even with the imperfect information which we possess on the subject, to view, without great satisfaction, the advantages that it holds out in perspective. If it shall be found expedient to take a formal possession of this bank, which lines the northern barrier of our own country, we may calculate on a considerable and important addition to our commercial intercourse with the continent. At the same time, in immediate reference to British subjects, we give employment to a numerous body of seamen, whilst an opportunity is afforded them, by purchasing small shares of vessels manned by themselves, of investing, to the greatest advantage, the profits of their several labours in remoter climates †.

Lastly, the improved state of our coasting navigation may justify the expectation, that from this northern source, an economical and nutritious food may eventually come within the reach of the populous districts of our manufacturing counties, the alleviation of whose distresses is at present so actively engaging the attention of the most enlightened of our countrymen. In fact, under whatever view we contemplate the discovery, it affords matter for the highest congratulation; and at a period when our country labours under unusual difficulties, every new accession to British resources will be hailed with double satisfaction.

⁂ Since drawing up the foregoing account, I have learnt, that the coast of Shetland has been visited by Mr Stevenson, civil engineer; and it gives me particular satisfaction to think, that the

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* The policy of an immediate examination of the exact situation, depth and extent of the bank, undertaken by Government vessels, seems particularly obvious.

† It is worthy of remark, that several of the vessels which have fished this season, have, for their joint proprietors, sailors who have saved a little money in the navy or in the Greenland fishery. In Scalloway, a company of this deserving class of people were highly successful in the prosecution of their new object.

opinion which I have expressed on the importance of the cod-bank, should coincide with the sentiments of a gentleman much better qualified than myself to form a true estimate of the value of the discovery.

ART. XXVII.—*Account of M. Fresnel's Discoveries respecting the Inflexion of Light.*

THE *inflexion* or *diffraction* of light is a name given to the coloured fringes or bands of light which are seen without the shadows of opaque substances, and to the dark and luminous stripes which are formed within the shadows of minute bodies, placed in a divergent beam of light attenuated by transmission through a small aperture.

The successive labours of Grimaldi and Newton threw much light on this difficult branch of physical optics; but it made no farther progress till the beginning of the present century, when our distinguished countryman Dr Thomas Young gave a fresh impulse to the inquiry, and enriched the science with his beautiful law of interference.

The application of this law to various inexplicable phenomena of colours, did not fail to attract the notice of different philosophers; and such were the expectations of its leading to some satisfactory explanation of the phenomena of inflexion, that it was particularly recommended by the French Institute to the notice of the candidates for the prize which this distinguished body offered in 1818 for the best Theory of Diffraction. This prize was some time ago adjudged to M. A. Fresnel, engineer of roads and bridges, a philosopher of the highest promise, who had already signalised himself by his researches on the polarisation of light.

His discoveries respecting inflexion are in the highest degree important, and cannot fail to be regarded as affording a strong confirmation of the Huygenian theory of light. We have no doubt, therefore, that our readers will be gratified with the following summary of the principal results that are capable of being stated in a popular manner.

1. M. Fresnel found that the fringes formed by inflexion may be examined by an eye-glass, without receiving them upon a white surface; and by adapting a micrometer to the eye-glass, he was able to determine their breadths, even to the one or two-hundredth part of a millimetre.

2. By following the external fringes to their origin, by means of a lens with a short focus, he perceived the third fringe at the distance of less than the one-hundredth of a millimetre from the edge of the inflecting body.

3. The inflexion of the passing light is influenced by the distance of the radiating or luminous point from the inflecting body, as appears from the following results.

Distance of the radiating point from the body.	Distance behind the body where the inflexion was measured.	Angular deviation or inflexion of the red rays of the first fringe.
100 millimetres.	1 metre.	12′ 6″
6 metres.	1 metre.	3 55

Hence it follows, that the ray suffers a less degree of inflexion in proportion to the distance from which it diverges.

4. When the inflexion of the same fringe is measured at different distances behind the inflecting body, the distance of the radiant point remaining the same, it is found to be different at different distances; and hence it follows, that the *successive positions of the same fringe are not in a straight line, but form a curve, whose concavity is turned towards the inflecting body.* The lines which join the different positions of the fringe of all the orders of colours, are hyperbolas, having for their common foci the radiating point and the edge of the inflecting body. In some of M. Fresnel's experiments, the *sagitta* of curvature was about 1 millimetre, or the 25th part of an inch, which is nearly 50 times greater than the error of observation.

5. M. Fresnel measured the fringes produced by various bodies, and found, by accurate measurement, that they all produced the same inflexion, the back of a razor giving the same fringes as its sharp edge.

Results of a similar kind were obtained by Dr Brewster in two sets of experiments, one of which was made in 1798, and the other in 1812 and 1813. He compared the fringes formed by gold-leaf, with those made by masses of gold; those formed by films which produced the colours of thin plates, with those formed by masses of the same substance. He examined the effects of *platinum*, *diamond*, and *cork*, in inflecting the light; the effects of grooves in metallic surfaces, &c.; and of cylinders of glass immersed in fluids of the same refractive power: and from these he concluded, that the Newtonian theory of inflexion could not be true; that the inflexion was not produced by any force inherent in the bodies themselves, but arose from a property of the light itself, which always shewed itself when divergent light was stopped in its progress *.

6. The fringes in the interior of the shadow, were first explained by Dr Thomas Young. He shewed in the clearest manner, that they were formed by the interference of two portions of light coming from the opposite sides of the inflecting body. Having introduced the sun's light into a dark room, through two small holes very near each other, he received the admitted light upon a sheet of paper from each of the holes separately, and observed no particular effect. But when the light was admitted through both the holes at the same time, so as to interfere, a series of obscure and brilliant fringes was produced.

M. Fresnel obtained a similar effect, by reflecting light from two metallic mirrors slightly inclined to each other, and whose surfaces were nearly in the same plane. The formation of these bands depends on the lengths of the paths of two interfering portions of light. When the paths are exactly of the same length, the two portions of light will form a brilliant fringe, having an intensity greater than that of either portion. If the next brilliant fringe corresponds to a difference of paths equal to d, then other brilliant fringes will be formed when the differences of the paths are $2d$, $3d$, $4d$, &c. When the differences of the paths are $\frac{1}{2}d$; $d+\frac{1}{2}d$; $2d+\frac{1}{2}d$, or $\frac{1}{2}d$, $\frac{3}{2}d$, $\frac{5}{2}d$, the interfering portions neutralize or destroy one another, and consequently produce a black fringe. The quantity d has a different value for the rays of different colours, and varies as the length of the fits in Newton's theory. M. Fresnel has found d to be $\frac{64}{100,000}$ of a millimetre for red light.

This beautiful theory of Dr Young is embraced by M. Fresnel. Both these philosophers had ascribed the exterior fringes to the interference of the direct rays with rays reflected from the margin of the inflecting body. M. Fresnel, however, has since found, that this explanation is insufficient; for the real place of the fringe is sometimes $\frac{17}{100}$th of a millimetre different from what it should be upon this supposition; and, at any rate, if the hypothesis were true, the extent and curvature of the margin of the inflecting body would have an influence upon the intensity of the fringes, which is contrary to experiment. He is, therefore, obliged to admit, that the rays which pass at a sensible distance from the inflecting body, are made to deviate from their primitive direction, and concur also in the production of the coloured fringes.

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* See *Journal of the Royal Institution*, vol. ii. p. 207.

It is by no means easy to explain to general readers the hypothesis by which M. Fresnel has accounted for the fringes upon the principle of interference; but we shall attempt to make it as intelligible as possible.

Let AME, Plate IV. Fig. 5. be a luminous wave or undulation, propagated from the radiant point C, and partly intercepted by the inflecting body AG. Then, if we suppose it divided into an infinity of small arcs A*m*, *m*′*m*, *m*M, M*n*, *n n*′, *n*′*n*″ &c., M. Fresnel obtains the intensity of any point (P) of the wave AME, when it has reached the position BPD, by supposing elementary waves to be propagated from every point *m*, *m*′, M, *n*, *n*′, &c. of its preceding position at AME. These elementary waves are propagated in all directions, and with intensities sensibly equal when they do not deviate much from the perpendicular. M. Fresnel does not take into account the waves which are much inclined, and which, according to his hypothesis, destroy one another; and in this way he determines the intensity of the light resulting from the reciprocal influence of all the rays which are slightly inclined to the perpendicular. By thus combining the principle of Huygens with Dr Young's law of interference, he has obtained a formula which represents the observations with surprising accuracy.

7. The phenomena of inflexion are considered by M. Fresnel to be inexplicable on the Newtonian theory of the emission of luminous particles; while almost all of them may be directly deduced from the Huygenian Theory of Undulations *.

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* Such of our readers as are desirous of farther information respecting M. Fresnel's discoveries, are referred to the *Ann. de Chim. et de Phys.* tom. xi. p. 246 & 337,

ART. XXVIII.—*Some additional facts relating to the habitudes of the Hyposulphurous Acid, and its union with Metallic Oxides* [*]. By J. F. W. HERSCHEL, Esq. F. R. S. Communicated by the Author.

IN order to procure the hyposulphite of silver in a state of purity, it is not enough to precipitate a solution of silver by a neutral hyposulphite. This, as I have shewn in a former communication, gives a mixture of the salt with sulphuret of silver. Nitrate of silver, somewhat diluted, must be poured into a pretty strong solution of hyposulphite of soda. A copious precipitate falls, white at first, but, as the precipitation proceeds, becoming gradually dirty, and at length quite brown, especially if too much of the nitrate be added. This precipitate, separated by the filter and washed, must be treated with ammonia, which dissolves the metallic salt, but leaves the sulphuret behind which contaminated it. The ammonia being exactly neutralised by weak nitric acid, the salt precipitates in a snow-white powder, which must be separated and dried as quickly as possible by violent expression, between folds of blotting paper. This salt is little soluble in water, has a sweet taste, and undergoes spontaneous decomposition very rapidly when kept exhaling sulphurous acid, and passing into a sulphuret, or, more probably, from the analogy of the hyposulphite of lead, into a sulphuretted oxide [†].

The habitudes of this acid with the oxide of mercury are not less singular than its relations to that of silver. The red oxide of mercury is readily dissolved by a solution of hyposulphite of soda, while the alkali is set at liberty in a caustic state. The solution has a sweet but, at the same time, a mercurial taste, and speedily becomes turbid on standing, or on evaporation, even under an exhausted receiver, depositing cinnabar in abundance. The hyposulphite of mercury, then, like that of silver, though formed in opposition to the strongest affinities, is readily destroyed by the tendency of its metal to enter into a more intimate union with sulphur.

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where the principal part of his memoir is published; and also to M. Arago's report upon it, in tom. xi. p. 5.

[*] See vol. i. pp. 8, and 396.

[†] See vol. i. p. 25.

Hyposulphite of Mercury and Potash.—On a quantity of orange carbonate of mercury, I poured a solution of hyposulphite of lime: It blackened, and a considerable portion dissolved. Into this I poured an excess of carbonate of ammonia, which separated the very small quantity of lime still remaining in solution, but left the oxide of mercury. Being cleared by filtration, carbonate of potash was poured in, when a white crystallised salt separated in abundance. The liquor, when moderately heated, grew turbid, and deposited a quantity of vermilion of the richest colour, after which it underwent no farther decomposition, even by continued ebullition, and on filtering and cooling, deposited abundant crystals of the same salt. This is a double hyposulphite, analogous to that with silver for its base. It is much more soluble in hot water than cold, and crystallises, in cooling, in spicular tufts. By careful management, however, it may also be obtained in oblong rectangular tables, bevelled at all the edges, or, which comes to the same thing, flattened six-sided prisms, terminated by two planes set on the longer edges. These are colourless and transparent, and their optical properties, on exposure to polarised light, present anomalies of a very extraordinary nature, which may be described more properly on some other occasion.

The action of oxide of lead on a liquid hyposulphite, is analogous to that of the oxides of silver and of mercury, but less strongly marked. When hyposulphite of soda was ground with litharge, no sensible effect was produced; but on allowing the mixture to stand twenty-four hours, the litharge became caked together, and its surface to some depth was found converted into a white mass. The supernatant liquid had now acquired a very sensible causticity, and immediately turned vegetable blues green, &c. The decomposition, however, proceeded no farther, and was never complete. The brown and red oxides of lead produce no such effect, nor have any other of the metallic oxides or hydrates which I have tried any considerable action.

I cannot forbear noticing here, though not relevant to the present subject, a phenomenon which occurred to me in the preparation of mercurial salts for some of the foregoing experiments. I had procured a quantity of the crystallized proto-nitrate, which forms when dilute nitric acid is allowed to remain in a moderately warm temperature on excess of metallic mercury. The action of water resolves this, as is well known, on a super and sub salt. The crystals being ground in a glass-mortar with repeated effusions of distilled water, the powder preserved its brilliant whiteness till the third or fourth affusion, when suddenly, while grinding and mixing it with fresh water, it passed to a sombre greenish-yellow hue, almost in an instant. I continued to grind it, and the colour heightened; but, to my great surprise, having desisted a few moments, my attention being taken off, I found, on resuming the grinding, that the yellow-green colour had again disappeared, and the powder had passed to a light ash-grey, almost white, and seemed to have become rather more bulky and crystalline. In its chemical properties it had undergone no change, dissolving readily, as I had expected, in dilute nitric acid, and affording a solution similar in all respects to that obtained by water in the course of the washing and grinding.

As the quantity operated on was rather considerable (perhaps 2 oz.), and the change of colour simultaneous over the whole mass, there is little doubt of a sudden subversion of equilibrium and a new arrangement of the molecules accompanying this phenomenon, though why it should take place at this precise epoch, seems difficult to explain, the abstraction of the acid having been going on gradually from the beginning.

SLOUGH,
Nov. 1819.

ART. XXIX.—*Notice of a Mineralogical Journey through South, North and East Iceland**, by Mr JOHN MENGE of Hanau †. In a Letter addressed to Professor JAMESON.

AT the foot of the Eyafialla-Jokulls, I satisfied myself that the Westmanna Islands, which are eighteen English miles from

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* We regret that want of time forces us to delay the map illustrative of Mr Menge's route, until our next Number.—ED.

† Mr Menge embarked at Copenhagen for Iceland on 19th May 1819, and reached the Westmanna Islands, off Iceland, on 9th June. After a short stay there, he landed on Iceland, and proceeded to Reikiavig, examining the country as he went along. From Reikiavig, he crossed the whole island to Skagafiord, a jour-

Iceland, were formerly continuous with it [*]; and was informed that the volcano of Heima-Ey, in one of the Westmanna Islands, was formed probably by a subterranean communicating canal, during an eruption of Eÿafialla-Jokull.

On the latter, as well as in the former, I observed three different streams of lava, separated from each other by layers of trass, which appear to have been formed after the eruption of the lava, by ejected masses and volcanic ashes. In the lowest bed, which is a porphyritic lava, I observed imbedded fragments of granite, gneiss, and syenite. The examination of these fused porphyritic rocks, made me fancy myself transported to the Lake of Laach, on the banks of the Rhine; but as I expected to find all the productions of Vesuvius and the Lake of Laach on the mainland of Iceland, I did not delay to search for them in this quarter [†]. Although the trap-rocks *(thonige massen-*

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ney of great difficulty and of much danger. He examined the north coast of Iceland from Skagafiord to Myvatn, and from Myvatn he proceeded eastward to Vopnafiord, and then south-east to Eskefiord, Berafiord, and Hammersfiord. He took his departure from Eskefiord on the 4th October, in a vessel bound for Copenhagen, but which put into Leith, in order to discharge part of the cargo, when we had the pleasure of making his acquaintance. During our conversations with him, we found that he had seen and examined more of the mineralogical structure of Iceland than any of those travellers who had preceded him. We expressed a wish to have a short account of his journey, and Mr Menge transmitted to us in German the communication of which we now present a translation to our readers.—Ed.

[*] According to Menge, there is a ridge of rocks, extending under the sea from the Westmanna Islands to the mainland of Iceland,—a fact illustrative of the opinion in regard to their former connection stated above.—Ed.

[†] We insert the following notice respecting the Lake of Laach, in order that our readers may understand the allusion to it in the text. Trap, or volcanic tuffa, abounds around the lake, and incloses balls of *porphyry-lava* and *felspar-lava.* The first, or porphyry-lava, contains abundance of glassy felspar, mica, olivine, augite, and fragments of burnt grey-wacke, which pass into a kind of pumice: the second, or felspar-lava, is a mixture of felspar and hornblende, and contains titanite, octahedral magnetic iron-ore, haüyne, iolite, sodalite, nepheline, &c. Around the lake, streams of *basaltic-lava*, are to be seen. At Niedermennich, there is a quarry of this lava, which is used for mill-stones. A few miles from the lake, there is a whole hill of tuffa, containing numerous beds of *leucite-porphyry*, in which there occur imbedded mica, sphene, and glassy felspar. Underneath these volcanic rocks, lie porphyry-slate, and various other trap-rocks; and these again rest on grey-wacke, that rock on which all the trap-rocks along the Rhine rest. The Lake of Laach itself appears to be the crater of an extinct volcano.—Ed.

gebirge) in Iceland, as in most other countries, rest on granite, and its congenerous rocks, yet here they are less frequently separated from them by the clay-slate formation than on the Rhine, and in the Rhone, and Vogelsgebirge; yet the limestone connected with this slate formation occurs in the Westmanna Islands, viz. on the north side of Heÿma-Eÿ and Barner-Eÿ. The limestone is compact and bituminous, with a strong argillaceous smell. All the lavas on Heÿma-Eÿ and on Eÿafialla-Jokull are melted trap-porphyry, full of crystals of glassy felspar. I remarked, in regard to the latter mineral, viz. the glassy felspar, that it became less and less frequent in the lava as we advanced westward,—a circumstance which led me to the conclusion, that the principal formation of the whole island (which I consider to be trap-porphyry) extends from S.E. to N.W., from which there may branch out in all directions the different members of the trap series.

In order to ascertain the accuracy of this inference, it was necessary to execute a journey across Iceland from south to north, and which I accomplished from Geyser to Skagafiord. Unfortunately I obtained in this route but little satisfactory information, owing to the great devastation occasioned by fire and water in this line of journey. The bounding points of trap-porphyry must be Klofa-Yokull on the south-east, and Dranga-Yökull on the west *.

In the Rangaarvalle Syssel, which I passed through on my way to Reikiavig, I could not make any observations, because the whole plain along the base of Hekla, proved to be an alternation of marsh, sand, and rapid streams. On the river Thiorsaa, I observed below a bed of volcanic sand, a species of tuff, with an obsidian basis. In the Guldbringe Syssel, which resembles a congealed Pandemonium, every rock has been melted. Although all the lava here is melted basalt, yet, it is worthy of remark, that the lava varies very much in its aspect, and may be described as forming three different kinds of *terrain*. The *first terrain* is cracked in all directions, and the slaggy masses appear confusedly aggregated together. In transverse sections, the lava presents five, six, or seven sided columnar concretions *. The mass or rock is compact, and differs but little from basalt. This kind of lava, which may be named *basalt-lava,* has often flowed to a considerable extent, sometimes with a smooth surface, sometimes with a surface resembling that of water when a gentle breeze begins to blow over it. Further, it is cavernous, the hollows or caverns appearing to have been formed by internal heat during the cooling of the surface of the lava. The *second terrain* is generally either in waves, or the rock appears heaped together in masses, having a rough, denticulated, and knotted surface, which we cannot behold without horror, and over which it is impossible to travel more than four or five miles. The *third terrain* is formed of *spumous lava,* which is sometimes rolled into long and large cylindrical masses. Its colour is grey and red, and although much ironshot, is light. In this lava, we observe numerous small rose-like forms, with small craters in the middle, through which the flame had issued.

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* We recommend the reader to consult the map of Iceland in Henderson's amusing and interesting work, entitled, "Journal of a Residence in Iceland," and also the map of the south part of Iceland, in the well known work of Sir George Mackenzie, Bart.—Ed.

From Hilleraa to Reikiavig, onwards to Vidoe, Essian and Mossfell, all appears to be unmelted; yet the rocks are not without marks of the action of heat. Even in the neighbourhood of Havnefiord, I observed a felspar lava, (greenstone), with druses containing ice-spar and augite crystals. I afterwards found this rock frequently alternating with trap rocks,—a circumstance which proved, in my opinion, that this lava had not flowed in the form of a stream, but had been changed on the spot by the action of fire. The mass of the rock was more compact all around Reikiavig, and appeared as basalt at Vidoe. The amygdaloid formation, with alternate beds of wacke, basalt, trap-porphyry, greenstone, &c. first appears at Essian. This formation is often traversed by veins, which are principally of compact basalt, obsidian, greenstone, and which sometimes contain a quartz which includes iron-pyrites. The beds frequently contain jasper, opal, zeolite, and calcedony. At Mossfell, there are beds and veins of an *obsidian-breccia,* which passes into basalt-tuffa.

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* The fact of *stream-lava* occurring in columns like basalt, has been denied by many naturalists; but the observations of Menge appear decisive as to this point.—Ed.

In my journey from south to north, I found a perpetual alternation of true volcanic and pseudo-volcanic rocks. The latter are principally formed by *Water*, or *Aqueous Volcanoes.* At the Huernafell, near to the Geyser, where there is also lava which has flowed, I found principally trap-porphyry. In a heap of debris brought down by the Bergwasser, I observed a number of masses which appeared like sandstone; but I was inclined to deny the existence of sandstone here, as I had not met with any quartz rocks which could afford materials for this sandstone. I found this rock afterwards in Nordland, and ascertained it to be an ironshot trap-tuff [*]. The Blafell, beyond the Geyser, is of pseudo-volcanic formation. We found here, besides half-burnt basalt, also a quantity of porcelain-jasper, which originated from the ironshot trap-tuff. The trap-porphyry is here again the predominating rock. On the Blafell, as well as on the *Bald* and Hoffsjokulls, the Neptunian destruction is as dreadful as the volcanic lava of Kiolfell, which lies between the two latter. This destruction appears to have been occasioned by the glacier ice during the eruption of the Kiolfells and Baldjökulls. The whole country is so covered with ruins of rocks that it is with the greatest difficulty we can make our way through it. After passing these debris, we enter the valley of Suartä, and immediately into the lava-flood of the Kiolrhaun. Although every thing around us appeared solid and secure, we were often about to sink into rents of the lava filled with mud, which had been poured into them by snow and glacier-water. The lava of Kiolfell has the same kind of surface as that of the Guldbringe Syssel; but it is more of the nature of melted basalt than of melted trap-porphyry. On the edge of the Kiolenrhauns, is situated the district of hot-springs named Huera-vellir. We now travel through an extensive district of volcanic sand, in which I frequently found small pebbles of obsidian, and of compact basalt-lava, to the valley of Blanda, through which the road leads to the rocky shore of Mälefell. The structure of the trap formation of Mälefell, on both sides of the romantic Firth of Skaga, is very striking. All the members of the trap series are arranged above each other in horizontal beds. Some may be inclined to view these beds as streams of lava, formed at different periods. With the exception of Mälefell, and the Tindastoll, which are to be considered as the extremities of a mountain-range, and which exceed all the mountains of the range in height, all the other mountains appear of the same elevation, and have a tabular form *. The beds of which these hills are composed, are the following:—a. *Calcedony-wacke.* b. *Amygdaloid.* c. *Amygdaloidal Porphyry.* d. *Trap-porphyry.* e. *Greenstone.* f. *Basalt.* g. *Stilbite-wacke.* h. *Amygdaloid,* with *Chabasite;* and generally we have again the same succession, beginning with calcedony-wacke †. On the Tindastoll, particularly on the east side, I almost fancied myself in the vicinity of Schemnitz in Hungary. I found here the whole formation of that neighbourhood. I observed very characteristic varieties of clay-porphyry, which often pass into hornstone-porphyry; also pitchstone-porphyry, pearlstone-porphyry, and obsidian-porphyry. I was particularly struck with the rock-crystals, which we observed lining the cavities of the calcedony-wacke, and which, in hand-specimens, could not be distinguished from those found in the mine of St Stephan in Hungary. The base of Tindastoll, as well as that of the whole mountain-range on the Firth of Skaga, is clinkstone-porphyry, to which also the porphyries just enumerated belong. All the mountain-ranges of Iceland which bound longitudinal valleys, are disposed conformably with the dip of the strata of the clinkstone-porphyry; and I was surprised to find, that while the unaltered rocks extend from S.E. to N.W. the volcanic occupy a ridge extending across these from S.W. to N.E. ‡. I ascended the Tindastoll from its east to its west side, partly with the view of examining the rocks in which the obsidian, which occurs loose at its foot, is contained, and partly to explore the wacke, in which I expected to find the precious opal; but the frightful and inaccessible nature of the rocks prevented all research. On the west side of the summit of Tindastoll, I found obsidian in roundish pieces, and in every possible variety. I was struck with the perfect resemblance of these to the varieties found in Mexico. I had the good fortune to find a great number of specimens of the *schillerende*, indigo-blue, green and striped kinds. The rocks in the vicinity of the obsidian appeared to be somewhat slaggy, and resembled those of the pseudo-volcanic class. The amygdaloidal beds were intersected by an opening several hundred paces wide, which I conceived might have formerly been filled with a vein of obsidian, thus affording a miniature representation of the great volcanic track which extends across the island, intersecting the trap-rocks. This appearance would enable me to explain the origin of obsidian from siliceous-sinter; the more particularly, as I had observed at the Geyser, and on the Huarevellir, the siliceous-sinter inclining to obsidian.

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[*] The same species of trap-tuff occurs near Kinghorn in Fifeshire.—Ed.

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* There is a view of the tabular trap-hills of the Skagafiord in the 2d volume of Henderson's Journal. They very much resemble the trap hills in Sky, Mull, and other parts of Scotland.—Ed.

† Menge names the beds from the predominating inclosed mineral: thus, in the calcedony-wacke, it is calcedony which is the principal included mineral.—Ed.

‡ It would appear from the observations in the text, that the volcanic rocks form a great ridge across the Neptunian trap-rocks.—Ed.

On the way from Tindastoll to Skagastrand, I discovered in Haller Valley a vein of obsidian. The obsidian appeared to pass into that coal which we often find in beds of flinty-slate.

The principal formation around Skagastrand is greenstone, which, like basalt, forms large groupes of columns. Nearly the whole of Spakonefell is composed of this greenstone, which very much resembles that of the Meissener in Hessia, differing from it only in containing augite in place of hornblende. At Spakonefell, I observed several beds of amygdaloid resting on the greenstone, in which the cavities were lined with the most beautiful crystallizations of analcime, chabasite, and mesotype. On my departure from Skagastrand, at the entrance of the Valley of Laxa, I rode over a vein of pitchstone, several hundred feet wide. In this mountain-chain, I crossed a valley named Vide, which appeared one of the most interesting geognostical spots in Iceland, but stormy weather, and want of time, prevented me from examining it. The most beautiful trap-porphyry, with magnificent crystals of glassy felspar; splendent calcedonies, pumice-porphyry, and masses of quartz-slate, with crystals of iron-pyrites; and the various colours of the rocky walls, all intimated very interesting phenomena in the district. From this to Liosavatn, I observed alternations of porphyry and amygdaloid. On the east side of Liosavatn, the *stream-lava* begins. We ascended from Skalxandafliot to the heath of Fliots, and passed through a long desert track of volcanic-sand to Mývatn, where a frightful scene of volcanic destruction was ornamented by beautiful groupes of volcanoes. On the east, the majestic Herdabried *; on the south-east from Mývatn, the Blafell, Burfell, Skogamanafell; on the north-west, Krabla, Hleirnuker, Eylifurfell, Giesdallsfell, Gusedallsfell, which surround the smoking white sulphur mountain of Namafell; on the south, the Seltlandafell; and on the north-west, the peaked Uindbelgias, with the numerous insular-looking eminences in the Mývatner lake, form a circle of volcanic mountains exhibiting every variety of form. The lava streams of Heirhnuker, and the great black crust of volcanic sand of Vogum, present a frightful appearance. We travelled over this dreadful volcanic desert, until we reached Vopnafiord in Easter Iceland. The lavas, as far as Liosavatn, were entirely basaltic; those of Hleirhuker somewhat porphyritic; while those of Herdubreid were the same as those of Eyafialla-Jokull. Basalt, amygdaloid and trap-porphyry, extend from Hoff in Vopnafiord across the heath of Smorvatn. The Valley of Fliot is an extensive district of columnar basalt and porphyry, through which the rivers Jökullsau and Lagerfliot have cut their channels. Wacke and amygdaloid are again the predominating rocks, from the Valley of Zungen across the heath of Eskifiard to Eskifiord. The whole mountain-chain on the north side of Rhödefiord, which is composed of beds of amygdaloid, calcedony-wacke, trap-porphyry, and stilbite-wacke, terminates at the Grakall, in the form of an ironshot calcedony-wacke, which rests on clinkstone-porphyry. The bed of stilbite-wacke often contains large cavities, which are filled with that beautiful variety of calcareous-spar named Iceland-crystal, or double refracting spar. The calcedony-wacke is either ironshot, when it contains jasper, stalactitic calcedony, and crystals of quartz; or it is without iron, and then we find, in place of the jasper, opal and calcedony. The beds of clinkstone-porphyry alternate with obsidian, pitchstone and pearlstone porphyries; and this formation appears to form the basis on which all the rocks of Iceland rest. The amygdaloid formation rises more from Eskifiord to Berufiord; and, like the formation which ends in wacke at Eskifiord, it also ends in amygdaloid at Diupavog in Berufiord. In the Breiddal, I saw different varieties of iron-basalt, which contained, in place of zeolite, frequently arragonite. I found the first traces of cross-stone in cavities of amygdaloid, in the heath of Gaga, associated with chabasite. Whilst collecting specimens of the different kinds of zeolite on the south side of Berufiord, I found the following beds of amygdaloid, with bases of wacke:

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* Henderson gives a representation of Herdabried and the vicinity, in a plate in his first volume.—Ed.

1. Compact wacke.
2. Wacke-amygdaloid, in which the cavities contain quartz.
3. Wacke-amygdaloid, with quartz, stilbite, and apophyllite.
4. Wacke-amygdaloid, with stilbite and green-earth.
5. Wacke-amygdaloid, with stilbite, much green-earth, and asbestous-zeolite or hair-zeolite.
6. Wacke-amygdaloid, with stilbite and mesotype.
7. Wacke-amygdaloid, with mesotype.
8. Wacke-amygdaloid, with mesotype, stilbite, and hair-zeolite.
9. Calcedony-wacke at the foot of the Bulandstind.

From Berufiord I visited Hammersfiord, the most south-eastern part of Iceland I had an opportunity of examining. Here I saw a great bed of clinkstone-porphyry in the amygdaloid formation. This bed is exposed at Röde-Skiuda, on the north side of Hammersfiord; and here I had the good fortune to find a series of rocks of the same nature of those which I was forced to pass without examination in the valley of Vide. Below a great bed of clinkstone-porphyry, I found a bed about six feet thick of pitchstone-porphyry, which passed on the one side into obsidian, on the other into pearlstone-porphyry. The bed dipped to the N.W. under an angle of 40°, and was traversed by small veins of compact basalt. The pitchstone is often amygdaloidal, and contains sphærulite*, balls of calcedony, jasper, magnetical pyrites, seldomer zeolite, and calcareous-spar, and only in the places where it touches amygdaloid. There is a small bed of white slaty clay between the porphyry-slate and the pitchstone. This bed of pitchstone-porphyry afforded me an explanation of the appearances in the obsidian hill near Krabla, where a similar bed appears to have been completely melted. Masses of porphyry-slate were still very discernible in the Krabla obsidian; and the sphærulite in the pitchstone, which the fire had converted into obsidian, appeared to be the same mineral as that found in Mexico, and described under the name *Equinolite*, and for which I would propose, as a more appropriate name, that of *Volcanic Sphærulite.*

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* Sphærulite occurs in the pitchstones of Arran, which very much resemble those of Hammersfiord.—Ed.

In the island of Heÿma Eÿ, there is only one place where fresh-water occurs, and it is in a track where volcanic rocks are wanting. On the Eÿafialla-Yokull there are portions of trap-porphyry still unmelted, and these afford fresh-water; but those parts which are in the state of lava afford none. The rivers Markerfliot, Thiorsaa, and Olvessaa, which flow through lava, arise from the glaciers. All those parts of the Guldbringe Syssel which are covered with lava, afford no fresh-water. At Cape Reikaness, there is a district of volcanic water situated in lava. In this district, also, there is a boiling marsh, of about 300 paces in circumference, which appears as if surrounded with fresh-burnt lava. The smoking parts which I dug up, were composed of a muddy hot mass, more or less mixed with sulphur, and of various colours, as blue, red, &c. I extracted several hard portions from the hot muddy mixture: these I broke when cold, and found, that in the centre they had the characters of basaltic lava, but towards the surface gradually passed into indurated red or grey mud. On an eminence in the neighbourhood, I observed whole deposites of siliceous sinter.

In the same manner as the hot-springs of Reikaness produce lava, we saw those of Krysuvick form basalt, and those of the Geyser trap-porphyry.

At Krysuvick in the south, and at Namafell in the north of Iceland, are great chemical laboratories. In both places, we almost see Nature in the act of forming sulphur, alum, silica, lime, oxide of iron, iron-pyrites, gypsum, basalt, lava, and porphyry.

In Iceland, we find volcanic and neptunian formations conjoined; the connecting link between the two, being the Volcanic-

Neptunian formation, which appears to be produced by hot-springs. In the whole volcanic region from the Guldbringe Syssel to Mývatn the formation of the hot-springs is abundant. We often observe members of the neptunian traps alternate with those of the volcanic-neptunian series, and also beds of true lava alternating with volcanic-neptunian trap. The first occurs at Essian, Mossfell, Blaufell, Ericks and Bald-Yokull, Tindastoll, &c.; the latter at Eýafialla-Jökull, Kiolfell, Hoffsjokull, and in nearly all the hills of Mývatn. In the whole southern track examined by Sir George Mackenzie, there is no pure neptunian trap, with the exception of some members of the series at Borgarfiord, which alternate with volcanic-neptunian rocks.

The lakes of Thingvalla-vatn, Huitaarvatn, Fiskevatn, Lisovatn, Mývatn, &c. were formerly districts abounding in hot-springs, which have fallen in, and formed the hollows now occupied by the water of the lakes. Beside the well-known hot-spring districts of Reikianess, Krysuvick, Geyser, Reikum, &c. in the south, there are many others in the middle of the island, and a great many in the neighbourhood of Mývatn, of which the most considerable are Hueravellir, Naumafell, Oxehver, Testareiker, and those at Odadarhaun.

We cannot maintain, that the silica in these hot-springs is derived from a quartzose solution, because quartz is one of the rarest minerals in Iceland. The siliceous-sinter, with all the other substances afforded by the siliceous water, viz. sulphur, gypsum, alum, bole, &c. disappear as soon as the water cools, and the residuum is trap-porphyry, basalt, and even amygdaloid.

The neptunian formation predominates in east and west Iceland, yet not without some occasional intermixture of volcanic-neptunian rocks. The greater number of veins that occur in these rocks, are volcanic-neptunian.

Observations by the Editor.

From the preceding short account, it appears, that Iceland is formed of four classes of rocks, viz. Neptunian or common Trap rocks, Volcanic-neptunian rocks, true Volcanic rocks, and Alluvial rocks.

1. The *Neptunian Trap-rocks* are the same as those met with in the Hebrides, and in our trap districts in the Mainland of Scotland.

The following are enumerated: 1. Trap porphyry. 2. Clinkstone porphyry. 3. Claystone porphyry. 4. Hornstone porphyry. 5. Pitchstone porphyry. 6. Obsidian porphyry. 7. Pearlstone porphyry. 8. Wacke. 9. Amygdaloid. 10. Greenstone. 11. Basalt. 12. Trap-tuff.

2. The *Volcanic-Neptunian* rocks, those namely which Menge maintains are formed from hot springs, are basalt, lava, tuff and trap porphyry. These rocks are said to be readily distinguished, even in hand-specimens, from true trap-rocks, and true volcanic rocks, by their external characters.

3. The *true Volcanic* rocks are lava, of which there are three kinds, Compact, Vesicular, and Spumous, also trass and tuff. Neither of these two latter tribes of rocks have hitherto been discovered in Scotland.

4. The *Alluvial* rocks are formed of debris from the three preceding classes.

The Neptunian trap-rocks extend through Iceland from S. E. to N. W., and are intersected by a great body of volcanic rocks, which runs from S. W. to N. E., and therefore cuts across the trap-rocks in the form of an enormous vein. The rocks formed by hot springs, called Volcanic-Neptunian Rocks, are not confined to any particular tract; on the contrary, they are very generally distributed throughout Iceland. And, lastly, it appears, that all the perennial springs in Iceland flow from Neptunian trap-rocks, never from true Volcanic rocks; but that hot springs issue from volcanic rocks. R. J.

ART. XXX.—*Historical Account of Discoveries respecting the Double Refraction and Polarisation of Light.* Continued from Vol. i. p. 296.

PERIOD II. *Containing the Discoveries of Christopher Huygens.*

A FEW years after the publication of Bartholinus's work on Iceland crystal, the attention of the celebrated Huygens was directed to the subject of double refraction. He was induced to begin this investigation principally with the view of obviating any objection that might be drawn from the facts discovered by Bartholinus, against his own theory of ordinary refraction, and he was led to the particular views which he has published, from a desire to assimilate the two classes of phenomena.

His researches on this subject form the *fifth* chapter of his *Traité de la Lumiere*, which is entitled *De l'estrange refraction du Cristal d'Islande.* This work was composed about the year 1678, and read to several of the learned individuals who then composed the Academy of Sciences ; but it was not published till the year 1690, when its author was resident in Holland.

After a few preliminary observations, in which he gives Bartholinus the credit of having discovered some of the principal phenomena, he supposes ABEF, Plate IV. Fig. 1. to be a piece of Iceland crystal, and conceiving one of the three obtuse angles, which form the solid angle C, namely ACB to be bisected by CG, he calls the plane CGHF, which passes through this line, and the side CF, the *Principal Section of the crystal.*

If the surface A B is now exposed to the sun, being all covered but a small aperture K in CG, and if a ray IK is incident perpendicularly at K, it will be divided at the point K into two rays, one of which KL, will be a continuation of IK, while the other KM, will deviate from KL towards C, by an angle of 6° 40′, but will still be in the plane CGHF. This ray will emerge at M in the direction MZ parallel to IK. Hence, since the point M, by the extraordinary refraction, is seen by the refracted ray MKI, the eye being at I, any point or aperture at L, by the same refraction, will be seen by the refracted ray LKI, LK being parallel to MK, if I is very distant. The point L will consequently be seen in the direction IRS, and as the same point is seen by the ordinary refraction in the direction IK, it will necessarily appear double.

If the ray now falls in the direction NO, in the plane CGHF, making an angle of 73° 20′ with CG, or nearly parallel to CF, which makes with FH an angle of 70° 57′, it will be divided at O into two rays, one of which will be a continuation of NO, without refraction, while the other will be refracted in the direction OQ, both rays being in the plane CGHF. This is true of all planes parallel to the principal section.

In order to determine the law of the two refractions, Huygens drew upon a smooth surface a black line, AB, Fig. 2. and two lines CED, KML perpendicular to it, and having their distance EM greater or less, according to the obliquity at which the refraction is to be examined. The crystal being placed upon E, so that AB is in, or parallel to, the principal section EG, place the eye above it, and the line AB will be seen single, but CD will be double. The ordinary image will be easily distinguished from the extraordinary image, from the latter being always more elevated, or from the former remaining fixed in turning the crystal, while the latter revolves round the ordinary image.

If the eye is now placed at I, perpendicular to AB, till it sees the ordinary image of CD coinciding with the part of CD without the crystal, let the point H be marked on the crystal, where the intersection at E appears. Let the eye be now taken towards O, in the same perpendicular plane, till the ordinary image of CD coincides with KL, and let the point N, where the intersection E now appears, be marked upon the crystal. The lines NH, EM and HE, the thickness of the crystal, being accurately measured, then joining NE and NM, the ratio of refraction will be that of EN to NP, because these lines are as the sines of the angles of incidence and refraction NPH, NEP. In this way Huygens found the ratio to be that of 5 to 3 at all incidences, as Bartholinus had previously determined.

In order to find the extraordinary refraction, he next withdrew his eye to Q, till the extraordinary image of CD coincided with KL; he marked the point R, and consequently obtained by measurement the ratio of ER to ES, or the ratio of the Sine of incidence to that of refraction. By numerous observations, he found that this ratio was not constant, but changed with the inclination of the incident ray.

In continuing his observations on the extraordinary refraction, Huygens found that it observed the following law: Let CGHF, Fig. 3. be the *principal section*, and SK, VK two incident rays equally inclined to the perpendicular IL, and KT, KX the extraordinary rays after refraction, the distances TM and XM of these rays from the point M, where the refraction of the perpendicular ray IK cuts the base GF, will always be equal. This law is also true in the refraction of the other sections.

Huygens next proceeds to explain his theory of double refraction, founded on the hypothesis of light being the undulations of an ethereal medium. He supposes the ordinary refraction to be produced by spherical undulations, propagated through the crystal, while the extraordinary refraction arises from spheroidal undulations, the form of the generating ellipse being determined by the ratio of the two refractions. He then proceeds to shew that the deviation of the extraordinary ray, calculated upon this hypothesis, agrees precisely with observation. As this part of Huygens' treatise is of a less elementary nature than the rest, we shall make it the subject of a separate paper in our next Number.

Huygens' Discovery of the Polarisation of Light.—After he had drawn up his treatise on double refraction, Huygens discovered what he calls " a wonderful phenomenon," or the polarisation of the two pencils of light formed by Iceland spar. Having taken two pieces of Iceland crystal, and held them with a space between, he found that if all the sides of the one piece were parallel to those of the other, as in Fig. 4., the two pencils, BC, BD, formed by the double refraction of the ray AB, were not doubly refracted in passing through the second crystal in the lines EF, GH; the pencil DG, which had been *regularly* refracted by the first crystal, being now only *regularly* refracted by the second, while the pencil CE, which had been *extraordinarily* refracted by the first, was only *extraordinarily* refracted by the second. The very same result took place, not only in the position shewn in the figure, but in all other positions, where the principal sections of the two crystals were in the same plane, and whether the two surfaces were parallel or not. " Now, it is wonderful," says Huygens, " why the rays CE and DG, incident from the air upon the lower crystal, should not divide themselves like the first ray AB. One would say that the ray DG, in passing through the upper crystal, must have lost what was required to move the matter which served for the extraordinary refraction; and, in like manner, that CE had lost what was necessary to move the matter which served for the ordinary refraction. There is, however, another fact which overturns this reasoning, which is, that when we arrange the two crystals, so that the planes which form the principal sections cut one another at right angles, then, whether the surfaces are parallel or not, *the ray* DG *which proceeds from the ordinary refraction, suffers only the extraordinary refraction in the lower crystal, and the ray* CE *which proceeds from the extraordinary refraction, suffers only the ordinary refraction.* But in all the other positions, infinite in number beside those which I have determined, the rays DG, CE divided themselves into two by the refraction of the lower crystal, so that from the single pencil AB there are formed four pencils, sometimes of equal brightness, and sometimes of different brightnesses, according to the different positions of the crystals, but which do not seem to have more light, when taken all together, than the single ray AB.

"When we consider (the rays CE, DG remaining the same,) that it depends on the position of the lower crystal whether these rays are divided or not, while the ray AB is always divided; we are obliged to conclude that the waves of light, in order to have passed through the first crystal, have acquired a certain form or arrangement, in virtue of which, by meeting the texture of the second crystal in *one position*, they are capable of moving the two different matters which serve for the two kinds of refraction; while by meeting the second crystal in *another position*, they have not the power of moving any of these matters. But in what manner this happens, I have not been able to form any satisfactory conjecture."

(To be continued.)

ART. XXXI.—*On a singular Developement of Crystalline Structure by Phosphorescence.*

IN prosecuting the experiments on the phosphorescence of minerals, published in our last Number, we observed a very remarkable phenomenon in a specimen of blue fluor-spar. When a thin slice was cut from this specimen, so as to be transparent, it resembled a leaf with veins inclined to the ridge or central line which divided it into two parts. The central line, and several of the veins were colourless; while some of the veins were of a deep amethyst colour, and others of a pale amethyst colour.

Upon placing this slice on a hot iron, in order to examine its phosphorescence, I was surprised to observe that the *phosphorescent matter was arranged in strata or veins* parallel to those of the specimen, and each stratum emitted a phosphoric light peculiar to itself, and differing from that of the other strata either in colour or intensity. Some of the veins discharged a purple light: others a yellowish-green light; others a whitish-light, and others exhibited no phosphorescence at all. The most singular circumstance, however, was, that the different strata of phosphoric light preserved their boundaries sharp and well defined, and were far more minute and numerous than the strata seen by a microscopical examination of the specimen.

The discharge of the phosphorescent matter, therefore, had displayed an arrangement of strata which could not have been detected either by the optician or the mineralogist, in the same manner as in a piece of chalky Tabasheer of an uniform whiteness, a veined structure is exhibited after the partial discharge of the oil which it had unequally absorbed.

In a future paper, we shall have occasion to point out the conclusions respecting the cause of phosphorescence which are indicated by this and other experiments. D. B.

ART. XXXII.—*Some Account of* Professor AMICI's *Discoveries relative to the Motion of the Sap in Plants* *.

PROFESSOR AMICI, in the course of a series of experiments with his newly invented catoptrical microscope, in which he employed only very small and delicate objects, and such as seemed to promise some interesting discovery in respect to their organization, made some very remarkable observations on the motion of the sap in the stonewort plant (*Chara*, Lin.), which he communicated to the public in a short treatise, afterwards inserted in the 18th volume of the Memoirs of the Italian Society.

So long ago as the year 1774, the Abbé Corti had remarked a sort of circulation of the sap in this very simple plant †. With the aid of his microscope, Amici has now discovered in it new laws of motion and new organs, which had escaped the observations of Corti, and which throw new light on the physiology of plants in general, and particularly on the much contested porous tubes of Mirbel, and their functions in the economy of plants. Professor Amici's experiments were made from the year 1814 to 1818; they were carefully noted in his journal, and are now fully and circumstantially described in the memoir to which we have alluded. The following is, in substance, the result of his observations.

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* Translated from Gilbert's *Annalen*.

† *Osservazioni microscopiche sulla Tremella e sulla circolazione del fluido in una pianta acquajuola, dell' Abate* Bonaventura Corti, *Prof. di Fisica, &c.* Lucca, 1774. 8vo.

In all the parts of this plant, in the most delicate fibres of the root, as well as the finest green tendrils of the stem and branches, we may observe a regular circulation of the sap which they contain; while transparent globules of various sizes are constantly and regularly moving in uninterrupted circulation, with a velocity gradually increasing from the centre towards the sides in two opposite alternating streams, up and down, in the two halves or sections of the same simple cylindrical canal or vessel (separated by no partition), which runs lengthwise through the fibres of the plant, but which is interrupted at certain intervals by knots, and closed up by a partition which limits the cyclus. The circulation proceeds thus throughout the whole plant, and in all its fibres, from one knot to another; and in every tract or portion limited, as above described, in itself, and totally independent of the rest.

In general, the motion is perpendicular up and down; in some fibres, however, it is spiral, so that the ascending streams, which were seen at first on the right hand, appear next on the left, and *vice versâ.* In the fibres of the root, the circulation is quite simple, as only one single central canal appears; but in the green tendrils of the plant, the great central canal is surrounded by a number of similar small vessels, which have all a similar structure; but in each divided from it by appropriate partitions, so that they may be completely separated from it, each of them having a similar perpendicular or spiral circulation peculiar to itself.

If one of these vessels be slightly tied, or bent in an acute angle, the circulation will be interrupted, as in the case of a natural knot, and will then proceed above and below the ligature or bend, as before, along the whole tract. When restored to its former situation, the original motion will also be renewed, provided the plant has not been essentially injured in that place, or the forced situation has not been too long maintained. The circulation will also continue in the one half of the tract, after the other has been cut off above the ligature.

If one of the vessels be cut through right across, the sap which it contains will not immediately and entirely flow out, but only that of the one half,—the stream, namely, which is flowing towards the cut,—while the other continues its course. Vinegar deadens the motion, and even prevents the flowing of the sap out of a divided vessel.

The vessels are formed of an exceedingly delicate, smooth, white, transparent membrane, with regular, parallel, greenish stripes, running in a perpendicular or spiral direction, according to the direction in which the sap circulates. Between the stripes of each half of the vessel, that is, between the two streams which run up and down, there is always a smooth interval of the membrane without stripes, of the breadth of five or six, or more stripes. Of these smooth intervals there are two in each vessel, exactly opposite to each other, and of equal breadth; and, between them, the stripes (which, so far as the vessel is perfectly cylindrical, are divided by the intervals into two equal semicircles) are equally distributed.

These stripeless intervals, which exactly intersect the diameter of the circle of the cylindrical vessel, form, as it were, the partition between the two streams; and here there is indeed no motion of the sap globules, or, at most, a very sluggish and interrupted circulation. These stripes, of which above an hundred may be counted in both semicircles of the vessel, are raised and fastened to the internal part of the membrane, and of different compactness and strength. Wherever they appear most compact, thickest, and strongest, and generally in that neighbourhood, and consequently towards the sides of the vessel, we shall always remark the strongest and most rapid motion of the sap globules. These stripes, therefore, have an evident influence on the mode and degree of the circulation.

When magnified 207,025 times *, these stripes appear to be

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* 455 times, according to the usual mode of reckoning: Amici gives the magnified superficies, and $455 = \sqrt{207,025}$.—Ed.

composed of small green globules, or small bodies of an irregular form, as if strung together like the beads of a rosary. They are distinguished from the sap of globules by their green colour; and they do not mix with them when flowing at the same time out of the divided part of a plant into water.

If the vessel be divided, many of the stripe-globules near the cut will separate from the membrane; those more remote, however, will remain attached to it, and preserve their stripe form, only their direction will undergo some change in consequence of the lost tension, and the stripes will appear bent into various curves, outwards or inwards, and in some places unnaturally approached to, or removed from each other; and in this case, the motion of the sap-globules, so far as it still continues, (for we have already observed, that all the sap does not flow out at once,) follows this new unnatural direction, and appears to proceed most rapidly in those places where the stripes have accidentally run thickest together.

If the membrane of the vessel be gradually pressed, all these stripe-globules may be forced by degrees in a mass out of the aperture made by the cut; and the membrane will then appear quite smooth, pure white, and transparent as glass. Vinegar causes these globules to come out singly, or in pairs, or several hanging together, like fragments of a chain, and then they appear bound to each other by an extremely delicate membrane.

Now, as the cause of the constant and regular motion of the sap in this plant cannot possibly be ascribed to any of the powers hitherto assumed by vegetable physiologists,—the capillary attraction, the alternate contraction and dilatation, or the irritability of the vessels, because these are evidently quite passive; while, upon the other hand, the symmetrical stripes above described, as composed of small globules, exhibit the most obvious influence, not only on the mode, but even on the degree and reality of the circulation; Amici conceives himself justified in assuming as an hypothesis, that these stripes are to be considered as voltaic piles, and that the motion itself is to be attributed to the influence of galvanic agency; and this hypothesis seems to be supported, on the one hand, by the construction of these stripes, and on the other, by the known fact, (although perhaps not yet sufficiently confirmed,) that by means of this agent, (galvanism,) water may be conducted over from the positive to the negative pole, raised, contrary to all the laws of hydraulics, above the level, and brought through the pores of a bladder, which, but for it, are otherwise impermeable.

It is rather remarkable that another natural philosopher was engaged in these curious and delicate investigations at the same time with Amici, and with the very same plant, and published the result of his observations in the same year. We allude to that eminent German botanist, Dr Martins, (at present naturalist to the King of Bavaria in the Brazils,) who, in the year 1815, wrote a treatise on the structure and the nature of the *Charæ*, which was read at the Royal Academy at Munich, and printed in the Transactions of the Leopoldine-Carolinian Academy of Naturalists *(Nova Acta Physico-medica)*, vol. i. Erlangen, 1818, 4to. Dr Martins investigated the internal organization not only of the *Chara vulgaris*, (to which the experiments of Amici were confined,) but also of the *Chara flexilis* and *hispida*; and he has communicated his observations very minutely in the memoir to which we have alluded, and to which we must at present refer our readers.

Previous to the experiments of Amici and Martins, Professor Treviranus of Bremen had made similar observations on the motion of the sap in these plants, but without attempting to ascribe it to the same principle which is adopted in Amici's hypothesis *.

The preceding observations derive still greater importance from the circumstance, that Professor Amici thinks he has discovered a similar organization in various other plants, particularly the *Tropæolum majus* and *Humulus lupulus*, which he examined for the purpose of investigating the porous tubes, discovered by Mirbel, and observed by other vegetable physiologists; and he also thinks himself justified in believing, that the small granular substances which Sprengel found in the cells of some plants, and which frequently exhibit a regular position, are in reality similar stripe-globules, forming a similar galvanic apparatus. It appears to him, therefore, by no means improbable, that the cause of the motion of the sap in all plants may be traced to the same principle and power, although under a variously modified organization.

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* See *Observations on the motion of the granular substance in some* Confervæ, *and one* Chara, in Weber's *Contributions to Natural History*, vol. ii. Kiel, 1810, 8vo.

Amici had been prepossessed against the porous tubes of Mirbel, which he considered as striped vessels, similar to those above described, and the alleged pores he held to be nothing more than symmetrically arranged globules, which, by an optical illusion, had the appearance of being perforated in the centre. Notwithstanding this preconceived opinion, however, and the natural prejudice in favour of his own theory, he became convinced of the contrary, discovered real pores, but found, at the same time, that these vessels were not sap, but really and indisputably air-vessels,—a fact which Link had previously maintained. Professor Amici farther discovered, that the *tubi fibrosi* of this and several other plants, which are their proper sap-vessels, possess similar stripes and globules.

We understand that this ingenious philosopher has also made some very interesting observations respecting the structure and motion of the globules in the bloodvessels of animals, which, we trust, will soon be communicated to the public *.

ART. XXXIII.—*Mineralogical Report, made by the Chief Engineer of the Grand Duke of Tuscany to his Serene Highness, respecting the Island of Elba* †.

PORTOFERRAIO and the forts of La Stella and Il Falcone, are built upon a hill of grey argillaceous schistus, as may be easily observed on the sea-side.

On the right of the road from Portoferraio to Rio, a short distance from the Porto del Ponticello, is a hill of indurated clay, containing crystals of quartz, some cubical, some irregular.

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* A notice of Amici's discoveries respecting the form of the globules of blood, will be found in the *Edin. Med. Journal*, vol. xv. p. 120.—ED.

† Extracted, by permission of the author, from Mr H. W. Williams' interesting Travels, about to be published.—ED.

In many places the rock has crumbled into a common clay, in which the quartz crystals are scattered unaltered.

Advancing towards Rio along the sea-shore, we pass the salt-works of Portoferraio. The hills are still composed of argillaceous schistus, covered at the summit by limestone. Rio itself stands upon a hill, in which the schistus and limestone are disposed in alternate beds.

Between Rio and Portolongone the only subject of interest is the mine of Terra Nera, which lies to the south-east of the latter city.

Between Longone and Capoliveri lies the plain of Mola, which, although the most fertile soil in the island, is abandoned to stagnant waters, and consequently to malaria, which renders it uninhabitable.

Capoliveri stands upon an argillaceous schistus, over the surface of which lie fragments of serpentine and limestone. In the vicinity is the Mente Calamita, or mountain of loadstone, so famous all over Europe, and which, if well managed by the government, would alone insure a subsistence to the wretched inhabitants of the island.

In the district of San Peiro, to the west of Capoliveri, is the great granite quarry of Sacchetto, whence, it would appear, that the ancients drew many of their columns. Three of the columns in the portico of the Parthenon, are of a similar stone. There still exist on the spot, in an unfinished state, several columns inscribed Opera Pisana, and a basin of great diameter.

Marciana is built upon the prolongation of the Granite Mountains, now sinking under the schistus. The mountains inland from it are the highest in the island, and so rugged as to be nearly inaccessible. Proceeding round to Portoferraio, we find nothing but the argillaceous schistus.

Small as the island is, it contains minerals which might produce an immense revenue.

Its mines of gold and silver may be overrated, but the granite and marble quarries are of immense value, and copper and sulphate of iron form two lucrative branches of trade. The loadstone of Capoliveri, and the iron of Terra Nera, might be worked to any extent, did not the government throw obstacles in the way of exportation.

The small Island of Pianosa, immediately adjacent to Elba, now entirely uninhabited, might be cultivated to great advantage. The ancient roads still remain, as also the ruins of baths. It has a great extent of land fit for the plough; 600 head of cattle might find pasture; and the olive and vine thrive well. Napoleon had begun to repair the harbour, and build a fort to protect it from the Algerines, and at the same time to clear out the fountains still in existence. Now, however, all these improvements are abandoned, and Pianosa remains uninhabited.

ART. XXXIV.—*Quarterly Abstract of the Diurnal Variation of the Magnetic Needle.* By Colonel BEAUFOY, F. R. S.

MONTHLY mean Variation of the Magnetic Needle,
Variation West.

		1817.	1818.	1819.
AUG.	Morning,	24° 31′ 16″	24° 34′ 40″	24° 32′ 33″
	Noon,	24 42 51	24 45 58	24 42 49
	Evening,	24 33 45	24 37 50	24 34 24
SEPT.	Morning,	24 33 02	24 34 29	24 32 29
	Noon,	24 41 36	24 45 22	24 41 35
	Evening,	24 34 38	24 37 28	24 33 27
OCT.	Morning,	24 31 06	24 35 36	24 33 27
	Noon,	24 40 46	24 43 28	24 40 08
	Evening,	-	-	-

ART. XXXV.—*Proceedings of the Royal Society of Edinburgh.*

Nov. 15. 1819. A Paper by Dr Brewster was read on the subject of *Circular Polarisation*, a name by which he proposes to distinguish the phenomena first discovered by M. Arago, along the axis of Rock Crystal, afterwards analysed by M. Biot, and subsequently discovered by MM. Biot and Seebeck in several fluids. M. Biot had shewn, that in some specimens of rock crystal, a certain succession of tints was produced by turning the analysing prism direct from *Right* to *Left*, while in other specimens, the same succession was developed by turning the prism in a retrograde direction from left to right. He detected a similar difference in fluids; and he concluded, that the cause of the phenomena resided in the ultimate particles of silex and the fluids, and was entirely independent of their mode of aggregation.

The principal object of Dr Brewster's paper, was to describe the co-existence of the *direct* and *retrograde* structure in the same mineral, and the entire extinction of the circular polarisation in the stratum which intervened between the two opposite structures. He discovered traces of circular polarisation in crystals with two axes, and detected some new properties of this interesting species of polarisation. Several arguments were adduced to shew, in opposition to the opinion of M. Biot, that in the case of crystals, or of solid bodies dissolved in fluids, the property of circular polarisation cannot belong to the ultimate particles.

Nov. 29.—At a general meeting of the Society, the following gentlemen were elected Office-Bearers and Counsellors:

Sir JAMES HALL, Baronet, President.

Right Honourable Lord Gray, }
Hon. Lord Glenlee, } Vice-Presidents.

Dr Brewster, General Secretary.

James Bonar, Esq. Treasurer.

Thomas Allan, Esq. Curator of the Museum.

PHYSICAL CLASS.

Sir G. S. Mackenzie, Bart. President.
Professor Alexander Irving, Secretary.

Counsellors from the Physical Class.

Mr James Jardine.
Honourable Captain Napier.
Dr A. Duncan *jun.*
Gilbert Laing Meason, Esq.
Professor Russel.
Dr Hope.

LITERARY CLASS.

Henry Mackenzie, Esq. President.
Thomas Thomson, Esq. Secretary.

Counsellors from the Literary Class.

Reverend Dr Jamieson.
Reverend John Thomson.
Reverend Dr Brunton.
Sir John Hay, Bart.
Professor Christison.
Hon. Baron Clerk Rattray.

Dec. 6.—At this meeting, a paper was read, containing farther particulars respecting the slide at Alpnach, and a notice respecting its recent demolition. This paper is printed in our present number, p. 112.

Dr Brewster laid before the Society a notice respecting the developement of crystalline structure by Phosphorescence. See this Number, p. 171.

A paper by Mr C. A. Busby was likewise read, containing an account of a method of forming parabolic surfaces, by giving a rotatory motion to a stratum of fluid. The mechanism for this purpose, consists in a combination of the principle of the syphon with that of Barker's mill. The author proposed to apply this idea to the formation of mirrors for large telescopes.

ART. XXXVI.—*Proceedings of the Wernerian Natural History Society.*

Nov. 27. 1819. TWO communications from Dr Traill of Liverpool were read. The first contained the description of a new species of Simia, resembling the Preacher Monkey of Pennant. It is common in the forests of Demerary, and five specimens were sent to England in 1817, by Charles Edmondston, Esq.; but the species does not appear hitherto to have been described. It is distinguished by the head being black and bearded; tail not prehensile, thickly set with black hairs, claviform; the body below is black, but the back is well clothed with an ochry-coloured fur. This gives the animal the appearance of being furnished with a jacket, and from this circumstance Dr Traill proposes to give it the trivial name of *sagulata.* The other communication consisted of the description of a new species of Felis from Guyana, also sent home by Mr Edmondston. It is nearly allied to the Puma of naturalists. It has a long tail; the whole body is spotless, and of a clear reddish-brown colour. Dr Traill proposes to distinguish it by the name of Felis *unicolor.*

At the same meeting, the first of a series of ornithological papers, by Dr Fleming of Flisk, was read, containing a minute description from nature of the Water-rail, with remarks on its habits.

At this meeting, being the first which had occurred since the visit of Prince Leopold to Edinburgh, it was proposed by the

President (Professor Jameson), and unanimously agreed to, that His Royal Highness should be enrolled as an Honorary Member of the Society.

Dec. 11.—The following gentlemen were elected Office-Bearers and Counsellors:

Robert Jameson, Esq. Prof. Nat. Hist. Edin. President.
John Campbell, Esq.
Sir Patrick Walker.
Thomas Mackenzie, Esq. M. P.
Robert Stevenson, Esq.
} Vice-Presidents.

P. Neill, Esq. Secretary.
Wm. Ellis, Esq. Treasurer.
James Wilson, Esq. Librarian.
P. Syme, Esq. Painter.

Council.

Dr David Ritchie.
David Falconar, Esq.
Thomas Sivright, Esq.
Dr Ja. Gregory *junior.*
Captain Thomas Brown.
Colonel D. Williamson.
William Newbigging, Esq.
Dr Samuel Hibbert.

Art. XXXVII.—SCIENTIFIC INTELLIGENCE.

I. NATURAL PHILOSOPHY.

ASTRONOMY.

1. *Comet of* 1819.—M. Bouvard has discovered the error which we pointed out in our last Number, p. 403., in his elements of the orbit of the comet of 1819. His new elements are,

Passage of the perihelion, 1819, June 28th, $5^{h}\,17'$, Mean time from midnight.

Longitude of the node, - - -	$9^{s}\ 3^{\circ}\,42'\,34''$
Longitude of the perihelion, - -	9 17 4 55
Inclination of the orbit, - - -	80 45 0
Perihelion distance, - - -	0.34007
Motion, - - - -	Direct.

These results agree very nearly with those obtained by our correspondent Mr Rumker, from Mr Pond's observations.

2. *Elements of the Orbit of the Planet Ceres.*—M. Westphal has published the following elements of Ceres for Jan. 0. 1818, and the meridian of Göttingen.

Mean longitude,	326° 51′ 7″
Mean tropical daily motion,	770″ 77 83
Longitude of perihelion,	147° 18′ 22″
Longitude of node,	80 45 19
Inclination of the orbit,	10 37 55
Log. of greater semi-axis,	0.4421029
Excentricity, (= Sin 4° 28′ 57″.9)	0.0781589

These elements were computed from six oppositions, compared with Gauss's Tables of Perturbations.

3. *Elements of the Orbit of the Planet Juno.*—The following elements have been computed by M. Nicolai, Director of the Observatory at Manheim :

Mean longitude at Manheim, Jan. 0. 1819,	117° 45′ 2″.84
Mean tropical daily motion,	813″.86981
Longitude of perihelion,	53° 32′ 56″.09
Longitude of node,	171 6 50.23
Inclination of the orbit,	13 3 37.29
Log. of greater semi-axis,	0.4263500
Angle of Excentricity,	14° 53′ 17″.44

4. *Geocentric Places of Pallas.*—According to M. Dirksen, the next opposition of the planet Pallas will be in 1820, Jan. 6ᵈ 20ʰ 16′ 41″ mean time at Gottingen, its longitude being 106° 0′ 16″.2, and geoc. lat. 54° 28′ 33″.2 south.

5. *Baron Zach on the Error of Repeating Circles.*—From numerous observations made by this active and able astronomer, and by M. Inghirami, he has concluded, that an error of from five to ten seconds may remain undetected, in the mean of many hundred observations with the 12 inch repeating circles of M. Reichenbach.

OPTICS.

6. *Inclination of the Resultant Axes of Crystals.*—The following measures of the inclination of the resultant axes of crystals with more than one axis, have been obtained by Dr Brewster :

Carbonate of strontian, - -	6° 56′
Spermaceti crystallised, - -	37 40
Sulphate of magnesia and soda,	46 49
A new mineral, - -	56 6
Epidote, - - - -	84 19

7. *Crystals with one Axis of Double Refraction.*—The following crystals have been found by Dr Brewster to have one axis of double refraction:

Positive Class.	Negative Class.
Oxide of tin.	Molybdate of lead.
Apophyllite from Fossa.	Carbonate of iron and lime.

Other crystals have been found to have one axis from the tints, but as the single system of rings was not seen, they have not been inserted here.

8. *Refractive power of Hyposulphite of Soda and Silver.*—Mr Herschel has found the indices of its two refractions to be 1.735 and 1.785.

9. *Nitrite of Lead.*—Mr Herschel has found the index of the ordinary refraction of this salt to be 2.322. He found also that it had two resultant axes. We suspect, however, that it may have been another salt, or may have contained impurities; as the nitrite of lead which we examined, and which was made by an able chemist, had no double refraction, and no polarising structure.

10. *Illuminating power of Gases.*—Mr Brande has recently found that the illuminating powers of *olefiant*, *oil* and *coal* gases, are as the numbers 3, 2, and 1, and that their heating powers are nearly in the same ratio.

MAGNETISM.

11. *Captain Scoresby on the anomaly in the Variation of the Needle.*—A very interesting paper on this subject, by our able correspondent Captain Scoresby, has been published in the *Phil. Trans.* for 1819, Part I. The following are some of the results of his observations:

1. All the iron on board a ship has a tendency to become magnetical, the upper ends of the opposite bars being S. and the lower N. poles in the Northern Hemisphere, and *vice versâ*.

2. The combined influence of all the iron is concentrated into a focus, the principal S. pole of which being upward in the N. Hemisphere, is situated in general near the middle of the upper deck.

3. This focus of attraction, which appears to be a S. pole in N. dip, attracts the N. point of the compass, and produces the deviation in the needle.

4. This deviation varies with the dip of the needle, the position of the compass, and the direction of the ship's head. It increases and diminishes with the dip, and vanishes at the magnetic equator. It is a maximum when the ship's course is W. or E., and it is proportional to the sines of the angles between the ship's head and the magnetic meridian.

5. A compass placed in either side of the ship's deck, directly opposite to the focus, gives a correct indication on an E. or W. course, but is subject to the greatest deviation when the ship's head is N. or S.

METEOROLOGY.

12. *Sir H. Davy's Theory of Mists.*—According to this eminent chemist, land and water are cooled after sunset in a very different manner. The impression of cooling on the land is limited to the surface, and is very slowly transmitted into the interior; whereas in water the upper stratum, when cooled, descends, and has its place supplied by warmer water from below. The surface of the water will therefore, in calm and clear weather, and in temperatures above 45° Fahr., be warmer than that of the contiguous land; and consequently the air above the land will be cooler than that above the water. When the cold air, therefore, from the land mixes with that above the water, both of them containing their due proportion of aqueous vapour, a mist or fog must be the result. *Phil. Trans.* 1819, Part I.

II. CHEMISTRY.

13. *New Alkali discovered by MM. Pelletier and Caventou in the Veratrum Sabadilla.*—In the prosecution of their researches respecting animal substances that have a decided action on the animal economy, these able chemists have discovered in the

the *Veratrum sabadilla*, an alkaline matter capable of crystallising, and endowed with an excessive bitterness. Their experiments upon this substance have not yet been completed. *Journal de Physique*, Aout, p. 155.

14. *Dr Clarke on the Alloy of Lead and Platinum.*—If pieces of platinum and lead be placed beside each other, and exposed to the heat of the blowpipe, there will be seen, when the platinum is heated, a beautiful play of blue light upon the surface of the lead, becoming highly iridescent before it melts.

15. *Experiments on Rock-Crystal and Glance-Coal exposed to the Heat of the Alloy of Tin and Platinum.*—When *rock-crystal in powder* is wrapt up in tin and platinum foil, and melted as in Fox's experiment, the fracture of the alloy is closer grained and has less lustre, than when the metals are melted by themselves: the combination of part of the silica perhaps occasions this difference of fracture. When a small piece of *rock-crystal* is heated in this way, there is an appearance of fusion on its surface. There is no appearance of fusion in *glance-coal* when heated in this manner, but it becomes *so hard as to scratch glass.* Dr Clarke heated *plumbago* with the gas blowpipe, and minute globules of transparent glass were formed on the surface; but since plumbago contains iron, it would have been better to have tried glance-coal, as it seems very refractory, and as most other substances have yielded to the gas blowpipe. If heated in the air, it would likely be dissipated; but it might be kept in a globule of platinum in fusion, and it would be seen whether it melted with this heat, or to what degree of hardness it was brought.

16. *Boracic Acid found in the Crater of Volcano.*—M. Lucas *junior* has announced, that he has discovered, among the saline concretions which cover the sides and the ground of the crater of Vulcano, a scaly and pearly crust, which, from its bitter taste, appeared to him to be *boracic acid.* This idea was completely confirmed by the experiments of D. Gioachino-Arrosto, a well informed chemist in Messina. *Ann. de Chim. et de Phys.* tom. xi. p. 44.

17. *Improvement on the Gas Blowpipe.*—It has been announced in the *Journal de Physique* for July 1819, that M. Berze-

lius has suggested a safety tube, filled to the thickness of two inches with circular pieces of fine wire-gauze, which was successfully tried in his presence by M. Barruel. This distinguished chemist was not aware that the very same improvement was suggested and used by our eminent countryman Dr Hope, who exhibited it to the Royal Society of Edinburgh on the 5th of May 1817. See *Journal of the Royal Institution*, vol. iii. p. 376.

18. *Purpuric Acid.*—In vol. i. p. 209, we have stated, that M. Vauquelin denies the existence of the purpuric acid discovered by Dr Prout. There seems to be no doubt, however, that this acid exists, and Dr Prout has ascribed M. Vauquelin's want of success to his having operated upon an impure lithic acid. Dr Prout always employed pure lithic acid, prepared from the excrements of the *Boa Constrictor*. In order to convince M. Vauquelin of his error, Dr Prout has transmitted to him a quantity of purpuric acid, purpurate of ammonia, and pure lithic acid.

19. *Specific Gravity of the Alloy of Tin and Platinum.*—The specific gravity of the alloy of tin and platinum, used by one of our correspondents who repeated the experiments of Mr Fox (see vol. i. p. 416), was found by Mr Jardine to be 9.7; that of the platinum being 21.0932, and that of the tin 7.308.

20. *Economical Scales for Thermometers.*—The late Dr Patrick Wilson, Professor of Practical Astronomy in the University of Glasgow, was remarkable for his great skill in the construction of thermometers. Such experimenters as happen now to possess any of them, value them highly. Many years ago, the writer of this notice heard the late Dr Moyse speak in terms of great approbation of Dr Wilson's thermometers; and mention as a remarkable fact, that notwithstanding their accuracy, the scales were generally engraved on paper. The Doctor could not conjecture by what contrivance the ingenious constructor could so accurately fit his instrument to his scale, instead of following the common practice of adapting the scale to the instrument. An opportunity afterwards occurred, of asking an explanation of the matter from Dr Wilson's son, then living at Hampstead, (but who died about eight or ten years ago.) He stated, that his father had a variety of paper scales printed

from copperplates. From these, he selected one to suit his thermometer nearly, but so as to have its division a little too near. This approximate scale he stretched, by passing it repeatedly through a pair of steel rollers, until he got it at last to fit his instrument with the requisite degree of accuracy.

III. NATURAL HISTORY.

MINERALOGY.

21. *American Tourmalines.*—Colonel Gibbs of New York, in Silliman's Journal, has given an interesting account of the discovery of green, red, and blue tourmaline, and of beryl, in a vein of felspar, which traverses a thick bed of granite, contained in mica-slate. The prisms of green tourmaline often enclose prisms of red tourmaline; and in some specimens there are three crystals of red tourmaline closely aggregated together, and enclosed in one crystal of green tourmaline. In other specimens, there are, in the centre of the green tourmaline, in place of the red tourmaline, iron-pyrites. These tourmalines are often traversed by transverse rents which are filled with felspar. This appearance is not uncommon in the schorls and tourmalines of this country, and has been considered as a proof of these crystals having been broken across by some mechanical force, and afterwards joined together by the felspar. This opinion we consider erroneous, because the felspar which crosses the crystals, is continuous with that which forms the mass of the granite; and as all the parts of the granite are of cotemporaneous formation, it follows that the tourmalines and their intersecting veins are cotemporaneous. Sometimes a thin layer of talc is contained between the outer and inner crystal. The largest crystal of red tourmaline found by Colonel Gibbs was one-fourth of an inch in diameter, and four inches long, and he remarked that they vary from translucent to semitransparent.

22. *Cave of Elephanta.*—The cave of Elephanta near Bombay, as appears from specimens in possession of a gentleman in Liverpool, is situated in amygdaloidal greenstone, which contains prismatoidal zeolite (stilbite.) The rock of this cave has

been described as volcanic; but the circumstance of its containing prismatoidal zeolite, proves that it is a Neptunian rock of the secondary trap formation.

23. *Jameson's Mineralogy.*—Professor Jameson has just published a new edition of his System of Mineralogy, in which minerals are arranged according to their external characters, and in conformity with the principles of the natural history method. Having now a system of mineralogy founded entirely on External characters, we shall look anxiously for one according to Chemical principles. It does not appear possible to form a consistent arrangement by employing external and chemical characters together. The method used in Professor Jameson's work, which is nearly that of Werner and Mohs, will form a department of the general system of Natural History, along with Botany and Zoology; while the chemical arrangement will fall to be considered as a branch of the general system of Chemistry.

24. *Vitreous Quartzose tubes of the Senner-Heath.*—In the second volume of the Transactions of the Geological Society of London, there is a particular description of vitreous quartzose tubes, about an inch and a half in diameter, and which sometimes descend 30 feet into the surrounding loose sand. The interior of these tubes appears to have been melted, and every circumstance of form and situation favours the inference of the member of the Society, that they have been produced by lightning. We have been lately favoured with a beautiful series of specimens of these tubes, collected at Irton by the original discoverer of them, E. L. Irton, Esq. of Irtonhall, Cumberland, and find, that they are of precisely the same nature as those which have been lately discovered in the Senner-heath in Germany. The vitreous tubes of the Senner-heath are situated in loose sand, have an inconsiderable diameter, but a length of from twenty to thirty feet, and their interior is slaggy and vitreous-like.

25. *Geognostical Situation of Topaz in the vicinity of Villa Rica in Brazil.*—The topaz mines are situated in chlorite-slate, which appears to rest on a sandstone of the primitive class. The topaz is said to occur in regular crystals, or in angular masses, or nests of lithomarge, along with rock-crystal.

26. *Mineral riches of the Capitania of Minas Geraes in Brazil.*—Probably no country in the world affords so much

iron-ore as the district just mentioned. Magnetic iron-ore, iron-glance, and compact clay iron-ore, occur not only in beds and veins, but forming whole hills and ranges of hills. In the same country there are repositories of ores of mercury, copper, tin, platina, lead, zinc, bismuth, and cobalt.

27. *Annual quantity of Salt raised from the bowels of the Earth in Europe.*—It would appear from a careful examination of the most accurate returns, that the European salt-mines and salt-springs afford annually from 25 to 30 millions of hundred weights of salt.

28. *Titanitic Iron-ore not confined to Volcanic Districts.*—Dr Thomson, in the second volume of the Wernerian Memoirs, gives an account of a variety of magnetic iron-ore from the primitive rocks of Greenland, which contains titanium. More lately M. Robiquet has found this metal in the octahedral magnetic iron-ore, imbedded in the steatite rocks of Corsica. These facts prove, in opposition to the opinion of Cordier, that titanitic iron is not confined to volcanic rocks.

29. *Sepia colour from Peat.*—The stagnant water in peat-bogs affords, on evaporation, a substance which affords a colour equal to that of the sepia.

ZOOLOGY.

30. *Spines on the Wings of Birds.*—Several tribes of birds are particularly distinguished by the spines that grow from their wings; the genera Parra, Palamedea, Struthio, and many Passerine birds are of this description. It has also been remarked by ornithologists here, that the winglets of the Rallus aquaticus are provided with spines, about the eighth of an inch in length.

31. *Patella distorta of Montagu.*—This rare British shell was first described by Müller, under the name Patella anomala. Poli afterwards examined it more particularly, and very properly considered it as constituting a new genus, to which he gave the name Criopus. Lamarck agrees with Poli in considering it as a member of a new genus, denominated in his system Orbicule. It has been lately found in Shetland by Dr Hibbert and Dr Fleming.

32. *Marine and River Mollusca in the Gulf of Livonia.*—The saltness of the sea-water is so inconsiderable in the Gulf

of Livonia, that fresh and salt water molluscous animals live together promiscuously on the same coasts. M. Freminville informed the Philomathic Society of Paris, that he collected from the same rocks species of the fresh-water genera Anodontes, Unio, and Cyclades, which were intermixed with species of the marine genera Tellina, Cardium, and Venus.

33. *Silk of the Pinna Marina.*—The pinna shell occurs on the Neapolitan coast, particularly on the shores of Calabria, and affords a kind of silk, which, after dressing, is wove with common silk, and made into various articles of dress. A pair of mens gloves cost 13 carlinis,—womens gloves 18,—pair of stockings 6 ducats,—waistcoat 30, and coat 100 ducats.

34. *Lepus variabilis or varying Hare.*—This species of hare occurs in the alpine districts of Scotland, seldom descends to the low country, and never intermixes with the common hare. In the north of Europe, there is a species said to be the same with our varying hare, but it differs from it in being larger, living in plains, and migrating in troops. The varying hare becomes white in winter. This remarkable change takes place in the following manner: About the middle of September the grey feet begin to be white, and before the month ends, all the four feet are white, and the ears and muzzle are of a brighter colour. The white colour gradually ascends the legs and thighs, and we observe under the grey hair whitish spots, which continue to increase till the end of October, but still the back continues of a grey colour, while the eye-brows and ears are nearly white. From this period the change of colour advances very rapidly, and by the middle of November, the whole fur, with the exception of the tips of the ears, which remain black, is of a fine shining white. The back becomes white within eight days. During the whole of this remarkable change in the fur, no hair falls from the animal: hence it appears, that the hair actually changes its colour, and that there is no renewal of it. The fur retains its white colour until the month of March, or even later, depending on the temperature of the atmosphere, and by the middle of May it has again a grey colour. But the spring change is different from the winter, as the hair is completely shed.

35. *Canary-Bird without Feathers.*—It is generally supposed that birds cannot live without feathers, or that they linger

out a miserable existence for a few days or weeks. This, however, does not appear to be true; for we find it stated in the Memoirs of the Society of Natural History of Wetterau, that a Mr Schæpf of Gottorf, reared a featherless canary-bird, which continued living and in good health for upwards of three years.

BOTANY.

36. *New Siliceous grass.*—In the hills between the Circars and the Nagpore country, a kind of jungle grass occurs in great abundance, in the joints of which *a very perfect siliceous deposit* is found. Dr Roxburgh makes no mention of it. This curious fact is contained in a letter from Dr Moore to Dr Kennedy of Edinburgh.

37. *Germination of the Musci.*—Mr James Drummond, Superintendant of the Botanic Garden at Cork, has lately made some very curious and important observations on the germination of mosses. He has succeeded in tracing the progress from the seed of nearly thirty species. The opinion of Linnæus, that the capsules of mosses were only antheræ filled with pollen, was properly rejected by Hedwig, but has been revived by Beauvois: the question may now be regarded as finally settled; for in Mr Drummond's experiments, the powder from the capsules never failed to germinate; and he uniformly obtained the same species of moss from which the capsules had been taken. He tried the seeds, both in earth and in water. In the former case, he previously torrified the earth, so as to exclude the possibility of other minute seeds existing in it in a state fit for vegetation: the earth having been thus rigorously purified, was put into garden-pots; these, again, were covered closely with small bell-glasses, and moisture was communicated to the pots by placing them in water that had been boiled. In the other case, he sowed the seeds on the surface of rain-water, and kept the vessel carefully covered. In the water, the germination proceeded with great rapidity, being visible the second or third day, when examined with the compound microscope. Mr Drummond found, that the seeds of all the different kinds of mosses produced at first similar articulated filaments. These Hedwig regarded as cotyledons, and Sprengel as minute confervæ: they are, however, neither cotyledons nor confervæ, but

germinating expansions of the seed itself, somewhat analogous to what is called the spawn of mushrooms. On the moist earth the process of germination is more slow: in a fortnight, however, the surface of the pots is covered with a substance resembling green velvet; and in about three weeks, the proper leaves begin to appear. It has long been suspected, that many of the small confervæ would require to be expunged from botanical lists: Mr Drummond's experiments will hasten this result: the well-known *Byssus velutina*, he ascertained to be nothing else than *Polytrichum aloides* in the first stage of vegetation. A full account of Mr Drummond's curious and important observations will probably appear in the next volume of the Transactions of the Linnean Society.

IV. GENERAL SCIENCE.

38. *George Bidder.*—This wonderful boy, who is only thirteen years old, and is well known for the singular faculty of performing in his mind the most complex and difficult arithmetical computations, arrived some weeks ago in Edinburgh for the purpose of exhibition. It occurred to a public-spirited individual, Henry Jardine, Esq. to whose benevolence and enlightened zeal most of the charitable and scientific institutions of this city have been under great obligations, that it would be highly desirable to rescue this interesting boy from being the subject of a public show; and having obtained his father's consent, he set on foot a subscription for providing him with the means of maintenance and education for some of the learned professions. The progress of his mind will be watched by some of the members of the Royal Society and the University. We shall be happy to be the channel of conveying to Mr Jardine the subscriptions of gentlemen not resident in Edinburgh; and we trust, that the friends of science in England and Ireland will contribute to promote this benevolent and useful scheme.

39. *New Society of Arts in Edinburgh.*—We understand that several gentlemen in Edinburgh have been occupied for a considerable time in establishing a Society for the Promotion of the Mechanical and Useful Arts in Scotland, for rewarding inventions of public utility, and disseminating useful knowledge

among the industrious classes of society. A leading object of the Society will be to erect a hall for depositing instruments, and models of machinery of all kinds.

40. *Method of taking Impressions of Gems and Seals in Shell-lac.*—Take a piece of mica, and put some lac upon it; hold it over the fire till the lac is softened, which must then be spread evenly over the mica: on the surface of the lac put a piece of gold-leaf or coloured foil, about the size of the impression to be taken; and cover this also with a thin layer of lac: it must now be softened at the fire, and the impression taken as with sealing-wax. The lac takes a very sharp impression; and the reflection from the gold-leaf gives the figures a fine relief. The mica is convenient for melting the lac upon, and the impression easily separates from it, leaving the back with a fine shining surface, and beautiful iridescent colours, occasioned by a thin plate of the mica adhering to the lac. The same piece of mica may be used for many impressions. In softening the lac, the heat should not be so strong as to make air-bubbles rise, as it is difficult to get quit of them again.

41. *Glass from Straw.*—Wheat straw may be melted into a colourless glass with the blowpipe, without any addition. Barley straw melts into a glass of a topaz-yellow colour.

42. *Experiments on the Colour of Minerals.*—The *Yellow Carnelian* may be changed into a fine red, by exposing it in a crucible with sand to a heat under redness. In India, "the stones are put into an earthen-pot, and covered with six inches of dry goat's dung: fire is then applied; and in twelve hours the pots are sufficiently cool to be removed." *Black Rock-crystal* may be made quite colourless by heat. Some specimens may be obtained of a yellow colour by not continuing the heat too long. The colour of the *Amethyst* may be taken away by a moderate heat: if the heat be increased, it becomes white and opalescent. The amethyst is more apt to crack with the heat than rock-crystal. The *Beryl* is changed with a moderate heat to a light blue: when the heat is raised, it becomes like mother-of-pearl. The *Emerald* has the same kind of pearly lustre when heated. The colour of the *Chrysoberyl* is not altered with a red heat. Dr Clarke exposed a *Diamond* of an amber colour

to the flame of the gas blowpipe: it became colourless and transparent; by continuing the heat it became white and opaque, and was volatilised. *Blue Fluor-spar* changes to a kind of red when heated, and when the heat is raised, it is often rendered colourless.

43. *Effect of Heat on Obsidian.*—A specimen of obsidian from the Island of Ascension, with blue veins in it, when exposed to a red heat, discharged air-bubbles from the veins more abundantly than from other parts of the mineral.

44. *Bottle thrown out of the Isabella.*—The bottle No. 2. thrown overboard by Captain J. Ross of his Majesty's ship Isabella, on the 3d June 1818, lat. 65° 40′ N. long. 54° 10′ W. off Greenland, to ascertain the direction of the current in Davis' Straits, was found by one of the servants of A. Macdonald, Esq. at Balranald, North Uist, on the 17th of July last, and the paper inclosed in it quite dry; so that it was 13 months and 14 days on its passage. The latitude of Balranald is about 57° 20′ north. The paper has been transmitted to the Admiralty.

45. *Earthquake at Lisbon on the 2d February* 1816.—The earthquake which was experienced at Lisbon on the 2d February 1816, at 0^h 4′ in the morning, and again at $6^h \frac{3}{4}$ in the evening, was felt by the *Marquis de Angeja*, a Portuguese vessel bound from Bengal to Lisbon, at 0^h 46′ (the time being reduced to that at Lisbon) and in lat. 34° 15′ N. and long, 15° 10′ W. from Lisbon. The vessel was therefore 270 leagues W. S. W. of Lisbon. The same earthquake was experienced on board another vessel bound from Brazil to Portugal, at 0^h 42′ (time at Lisbon), and again at 3^h 40′ in lat. 36° 56′ N. and 6° 52′ W. of Lisbon. The vessel was therefore 120 leagues W. S. W. from that city. The same ship again felt the shock at 5^h 57′. The first shock was therefore felt at the same instant nearly at three places very remote from one another. The same earthquake was said to have been felt in Madeira and Holland. *Ann. de Chim. et de Phys.* tom. xi. p. 323.

46. *Expedition overland from Hudson's Bay to the Shores of the Arctic Ocean.*—The expedition intended to examine the American shores of the Arctic Ocean, reached York Fort in Hudson's Bay on the 31st August, after having nearly suffer-

ed shipwreck in Hudson's Straits. The party proposed to leave York Fort for the interior on the 9th September. From want of previous arrangement in Hudson's Bay, however, the journey will occupy a longer time than was calculated upon. We are of opinion, that if intelligence had been sent out to York Factory, the party might have remained in London until March next, and then, by way of Canada, would have got up as far as they will be able to go next summer.

47. *Utility of the Marine Barometer, or the Sympiesometer, in indicating approaching Storms.*—The correspondent (Mr Stevenson, civil engineer) to whom we are indebted for the notice regarding the Scotch Fisheries, inserted in this number, (p. 129.) informs us, that having occasion, towards the conclusion of his voyage, in the beginning of September last, to visit the Isle of Man, he beheld the interesting spectacle of about three hundred large fishing-boats, each from fifteen to twenty tons burden, leaving their various harbours at that island in an apparently fine afternoon, and standing directly out to sea, with the intention of prosecuting the fishery under night. He at the same time remarked, that both the common marine barometer, and Adie's sympiesometer, which were in the cabin of his vessel, indicated an approaching change of weather, the mercury falling to 29.5 inches. It became painful, therefore, to witness the scene; more than a thousand industrious fishermen, lulled to security by the fineness of the day, scattering their little barks over the face of the ocean, and thus rushing forward to imminent danger, or probable destruction. At sunset, accordingly, the sky became cloudy and threatening; and in the course of the night it blew a very hard gale, which afterwards continued for three days successively. This gale completely dispersed the fleets of boats, and it was not without the utmost difficulty that many of them reached the various creeks of the island. It is believed no lives were lost on this occasion; but the boats were damaged, much tackle was destroyed, and the men were unnecessarily exposed to danger and fatigue. During the same storm, it may be remarked, thirteen vessels were either totally lost or stranded between the Isle of Anglesey and St Bees Head in Lancashire. Mr Stevenson remarks how much it is to be regretted, that the barometer is so little in use in the mercantile

marine of Great Britain, compared with the trading vessels of Holland; and observes, that though the common marine barometer is perhaps too cumbersome for the ordinary run of fishing and coasting vessels, yet Adie's sympiesometer is so extremely portable, that it might be carried even in a Manx boat. Each lot of such vessels has a commodore, under whose orders the fleet sails: it would therefore be a most desirable thing, that a sympiesometer should be attached to each commodore's boat, from which a preconcerted signal of an expected gale or change of weather, as indicated by the sympiesometer, could easily be given.

48. *On the Employment of Steam-Vessels for distant Voyages.*—As the application of steam to vessels crossing the Atlantic, or navigating to distant regions, is a subject of great importance, we have pleasure in recording the following observations by an intelligent correspondent, on the American steam-vessel the Savannah. Some account of this ship has appeared in most of the newspapers, and in some periodical works; but as the statements that we have seen speak altogether in favourable terms of this application of steam, it is only proper that the disadvantages of it should also be known.

The Savannah steam-ship, Captain Rogers, arrived at Liverpool on the 20th June last, after a passage from land to land of twenty-one days. The steam-engine was in use during eighteen days of the passage; which, being calculated to bear twenty inches of steam, operated, in moderate weather, with good effect. This vessel, though of 350 tons burden, is only calculated for carrying passengers; the whole hold being requisite for the stowage of coals sufficient for a twenty days passage. She is fitted up in a superior style, and has thirty-two state-rooms; the accommodation for ladies, which is in an *after* cabin, is very private.

The steam-apparatus in the Savannah occupies the greater part of the hold from the main-mast to the fore-mast; leaving only a small space in each side suitable for carrying coals. The engine is well finished, and the machinery neatly disposed. The water-wheels are affixed to a cast-iron axle-tree, passing through the sides of the vessel above the *bends*, which is incapable of motion in any direction, excepting that necessary for turning the water-wheels; but the water-wheels themselves are capable of being taken to pieces, and removed in bad weather, all excepting two principal arms of each, which being of cast-metal, and securely fastened, are placed in a horizontal position in high seas, and are productive of little inconvenience. What renders this experiment unfavourable to the application of steam to vessels trading to distant countries, is the immense consumption of coals, and the occupation of the whole of the stowage in the hold by the requisite coals and machinery. Hence there is no room left in the vessel but the 'tween-decks, for the cargo. Besides, the expence of coals only, which amounts to ten tons per day, (omitting the value of the machinery, and the loss of stowage), is more than proportionate to the advantage gained in the passage. The engine is of little service, excepting in moderate or in calm weather. In a fresh breeze, when favourable, a sufficient velocity is obtained without it; and when unfavourable, it is incapable of driving the ship against the wind.

It seems probable, therefore, that for general purposes, steam will not be found applicable as a power for propelling ships across extensive seas; being principally confined in its use to vessels carrying passengers.

49. *Plants impregnated with Carbonate of Lime mistaken for Coral.*—Captains Vancouver and Flinders, and M. Peron, observed on the shores of New Holland, at considerable heights above the level of the sea, arborescent calcareous productions, which appeared to them to be altered organic bodies. Vancouver and Flinders considered them as corals, and from their occurring high above the present level of the sea, around New Holland, inferred that the level of the ocean must have sunk. Peron says they are either corals, or vegetables incrusted with calcareous matter. Mr Clarke Abel met with similar appearances near Simon's Town, at the Cape of Good Hope, and has proved that these arborescent coral-like bodies are not coral, but vegetables impregnated with carbonate of lime. We recommend the perusal of Mr Abel's account, from page 308. to page 312. of his " Narrative of a Journey in the Interior of China," to our readers.

50. *Wine from the Arbutus unedo.*—In the Island of Corsica an agreeable wine is prepared from the berries of this plant.

51. *Map of Iceland.*—The Danish Government has resumed the trigonometrical and hydrographical survey of Iceland, which had been interrupted during the war. It is proposed to publish the map in seven sheets; three sheets we understand are already published. The care of the publication is committed to Admiral Löwenörn.

52. *Charts of the Baltic.*—Of late years the Swedes have been much occupied in hydrographical investigations. Much has been done under the direction of that excellent officer Admiral Klint; and lately, under his superintendence, there has been executed a series of charts of the Baltic, which are by far the most accurate hitherto laid before the public. The Danes remark of the English charts of the Baltic, with what justice we know not, that they are beautifully engraved, but very inaccurate.

53. *Greatest Waterfall in Europe discovered in Lapland.*—In the mineralogical report of Lapland presented to the Swedish Government, amongst other curious facts, the discovery of a great waterfall in the River Lulea is particularly mentioned. It is said to be one-eight of a mile* broad, and at its greatest height to fall 400 feet perpendicular.

Art. XXXVIII.—*List of Patents granted in Scotland since 11th September* 1819.

18. To James Ingledew, late of Little College Street, Westminster, now of White Street, Southwark, in the county of Surry, for his invention of "the means of effecting a saving in the consumption of the ordinary articles of Fuel, by the application of certain well-known materials hitherto unused for that purpose." Sealed at Edinburgh, 23d September 1819.

19. To James Bristow Fraser of Blackburn House in the county of Linlithgow, North Britain, for his invention "of cer-

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* Probably a German mile, which is equal to four and a half English miles.

tain Improvements in the application of machinery for Propelling Ships or other Vessels floating on Water, by means of an Hydraulic Apparatus, acted upon by a Steam-engine, or other adequate power." Sealed at Edinburgh 19th October 1819.

20. To John Sinclair, manufacturer in Edinburgh, for his invention "of an Improvement in the manufacture of Shawls, Plaids, Scarfs, Handkerchiefs, Gown-pieces, and other articles with which coloured threads are wrought into flowers and other fancy figures, in the process of weaving, whether the said articles are made of Silk, Cotton, Worsted Lint, Hemp, or other materials, or mixtures thereof." Sealed at Edinburgh 10th November 1819.

21. To William Good of Bridport Harbour, within the parish of Symondsbury, in the county of Dorset, ship-builder, for his invention of "an Improvement in the art of tanning Hides and Skins, and barking or colouring Nets, Sails and other Articles, by the application of well-known materials hitherto unused for that purpose." Sealed at Edinburgh, 20th November 1819.

22. To John Taylor of Bury Court, Saint Mary Axe, London, Engineer, for his invention of "a mode or means of producing Gas to be used for the purpose of affording Light." Sealed at Edinburgh, 20th November 1819.

23. To Robert Copland of Liverpool, in the county of Lancaster, merchant, for his invention of "a new and improved Method or Methods of gaining power by new or improved Combinations of Apparatus applicable to various purposes." Sealed at Edinburgh, 20th November 1819.

24. To Charles Attwood of Bridge Street, Blackfriars, London, for his invention of "A mode or modes of manufacturing Mineral Alkali and Vegetable Alkali, and the application thereof, (so far as relates to Mineral Alkali), by way of improvement on, or addition to, other modes heretofore known or in use, but more particularly in the manufacture of Kelp." Sealed at Edinburgh, 10th December 1819.

25. To Israel Gundry, Edward Neave and George Neave, all of Gillingham, county of Dorset, for their invention of "an application of various Gases or Vapours to certain useful purposes." Sealed at Edinburgh 10th December 1819.

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Art. I.—*On Peat.* By John MacCulloch, M. D. M. G. S. Lecturer on Chemistry to the Board of Ordnance, &c. Communicated by the Author. (Concluded from Page 59.)

In describing the natural solution of Peat in water, a few of its chemical qualities were necessarily mentioned. Those which remain to be noticed are of little or no moment in a practical view, nor are they such as to throw much light on the chemical nature of this substance, or on that of the process by which vegetable matter is converted into peat. Alcohol, ether, and the alkaline lixivia, extract from it a brown matter, analogous to, or identical with, that which has already been described as capable of being dissolved by water. On evaporating the two former fluids, this matter is obtained in a solid form, but, in the latter case, it combines with the alkali, so as to form a saponaceous compound, analogous to that which is produced by dissolving bistre or wood-tar in the same solutions. It is unnecessary to describe the results obtained from the action of the essential oils, ammonia, or the mineral acids; as they are either analogous to the former, or resemble those which the same substances produce with unchanged vegetable matter, and throw no light on the subject.

The object to be kept in view in the chemical examination of peat, is to determine the nature of the change which has taken place between the destruction of the vegetable organization, and the conversion of its substance into this new compound. It is more particularly interesting, to discover in what respect peat approaches to the bitumens, or rather to the bituminated lignites; since, through this latter stage, it must pass in its transition from the vegetable to the mineral class of substances. This question is more or less remotely connected with a very interesting train of geological inquiries. Peat has in fact been confounded with the bituminated vegetables, and has been supposed to derive its inflammable quality from the formation of bitumen during the process by which it has been generated. It will, however, be found, on a more strict investigation, that there is an essential distinction between common peat and bituminized wood, and that even when it does show some of the characteristic marks of the bitumens, the degree in which it has undergone this change is very limited. The Ince peat of Lancashire appears unquestionably to be accidentally penetrated by petroleum, derived from the usual source of a bituminous spring.

Although in a practical view, therefore, peat may be considered as an indefinite substance, and in a state of transition to bituminized vegetable matter, it is convenient for the present purpose to divide the process from the death of the vegetable to its bituminization, into two stages. The first of these comprises the change into mere peat, in which no traces of bitumen can be discovered, and the last may be conceived to extend from the time at which it first gives traces of this substance, to that in which the characters of peat have been replaced by those of bituminized wood. It will shortly be seen, that we are in possession of chemical means, by which pure bitumen can be distinguished from pure peat, or from that substance which constitutes its essence; and the application of the same powers enables us, although less perfectly, to distinguish that state to which alone the name of Peat should, for the sake of accuracy, be applied, from that in which the process of bituminization has commenced.

The powers of chemical analysis are as yet so limited, that we have no means of examining directly the differences of the various substances which are found throughout the whole of these changes, from the simple vegetable matter downwards; or, at least, the results which are obtained from the application of these means, are imperfect and unsatisfactory. But considerable light may be thrown on the subject, by that operation formerly considered as an analysis, namely, the application of heat in close vessels, or destructive distillation. By conducting this process in the usual rude manner, there are obtained a set of new compounds, together with a portion of the elementary constituents from which these compounds, and the original subject, are formed. With more care, a new set of compounds alone are obtained, and, in either case, these are again capable of being subjected to a new analysis, so as to furnish, in a sufficiently accurate manner, the required information. It is unnecessary for the purposes of this paper, to enter into any minute details on this subject, but it will be sufficient to state, that by examining the various nature and proportions of these compounds, as they are obtained from the different materials, or, if necessary, by again decomposing them into their elements, the proportions of these elements, under different circumstances, may be obtained with sufficient accuracy for the objects in view. Thus the progress of change in the vegetable matter, may be traced by the gradation in these proportions during the progress of that change; and thus also certain useful analogies may be discovered between peat under all its forms, and other compounds which differ from it rather in their mechanical than in their chemical nature.

If fresh vegetable matter, (and it is here most convenient to consider the ligneous substance), be subjected to distillation by a naked fire, certain volatile products are obtained, and charcoal remains behind. The chief of these volatile products are Tar *, a volatile oil, and acetic acid. A varying proportion of

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* I have given to this substance the name of Tar, because that name is so applied in the charcoal manufactories, where it is obtained in considerable quantity. The tar used for naval purposes, being always procured from fir by a similar process, is a compound of this substance and the turpentine of that tree. In the same manner the term of Pitch will here be applied to the solid material remaining after a gentle distillation of this tar; nautical pitch being a compound of common resin and this substance. The oil of turpentine, together with the oil of the wood, is separated in this latter case, as the oil of wood alone is in the former. I may here refer the reader to a paper in the second volume of the Geological Transactions, in which the subject has been examined in some detail with other views.

The pitch, in a certain state of hardness, is the Bistre of artists, on which some remarks will also be found in the same paper.

ammonia, often very minute, is also found, and this, as might be expected, is combined with the acid. When the process is irregularly conducted, a second process is carried on together with the first, and the new compounds become partially decomposed. Thus there is produced a gaseous substance, which is either hydrocarbonic gas, containing various proportions of carbon, or else a mixture of that gas and carbonic oxide. At times, according to the mode in which the process has been conducted, no essential oil is obtained, the whole of it being decomposed as fast as it is formed, and recompounded into the hydrocarbonic gas. But it may be procured by redistilling the tar, which thus becomes separated by a further decomposition into essential oil, pitch, and a fresh proportion of acetic acid, always holding, from its strong affinity to that substance, a portion of the inflammable compound in solution. The pitch, by continuing this process, at length loses its character, and becomes a brown or black friable mass, but still continues to give over volatile inflammable matter and acid, until it is finally reduced to the state of charcoal. Finally, it gives over hydrogen only, and acquires an extreme degree of hardness, as ordinary charcoal does in the same case, becoming also unsusceptible of further change. It may be remarked, that as the tar becomes pitchy, the essential oil, which was originally pale, and at first nearly colourless, becomes gradually darker, and that the volatile product of the solid pitch is not oil but tar, which is, however, capable of being decomposed in a similar manner by a repetition of the same treatment. It is obvious, that this is the consequence of the greater heat required in this case, to effect the separation of the volatile product.

In reconsidering the consequences of thus pushing the process to its extremity, it is apparent that the whole vegetable matter is or may, by further analysis of the acetic acid and the ammonia, be resolved into carbon, hydrogen, oxygen, and azote; that the proportions of these might, by a more laborious and accurate analysis, be discovered, and that they may be conjectured with sufficient accuracy for the purposes now in view, by attending to the several proportions in which these compounds are obtained.

In stating these results, I have neglected to notice the fixed salts and earths which remain after the incineration of the charcoal, as they are not essential to the present inquiry. That I may not return to this subject, I will here remark, that, in pure peat, their nature and proportion will depend on the nature of the vegetables from which it has been generated, and that while potash, for example, may be found in the peat of submerged wood, silica will occur in that produced from gramineous vegetables. But as alluvial earths are frequently mixed with peat, the earthy residuum of this substance is generally in greater abundance, and often indeed amounts to a considerable quantity. Agriculturists may hence judge how little advantage is to be derived from peat-ashes as a manure, unless in those cases where a considerable quantity of burnt clay has been produced by the operation.

If imperfect peat be now subjected to the same operations, the same results are produced, but the proportions of the different products will be found to differ. In the first stages of the decomposition of plants, these differences are not very sensible, but they become gradually more so, as the peat subjected to examination is more perfect. When perfect peat, not yet entered on the stage of bituminization, is thus examined, it will be found that the proportion of acid is sensibly diminished, and that the more solid new compounds also bear a larger proportion to the more fluid. There are, in fact, produced more pitch and less essential oil, and consequently a larger quantity of charcoal, in proportion to the volatile products, is obtained, in the distillation of peat, than in that of recent, or undecomposed vegetables. Neglecting the azote in this case, it is therefore apparent, that the principal chemical change from vegetable matter to peat consists in a dissipation of part of the hydrogen and of the oxygen. But this is not the only change, as the solubility of peat in the various fluids formerly enumerated, proves that a new combination has also taken place among some of the elements. This soluble matter is analogous to that which is produced from the same elements by the action of fire, and is in both cases a compound of hydrogen and carbon principally. In the process, therefore, of converting vegetable matter into peat, the proportions of the original ingredients are not only changed, but the carbon and hydrogen enter to a certain degree into a new combination together with a portion of the oxygen, forming a compound analogous to that which results from the action of fire. The action of air and water on vegetable matter is therefore similar to that of fire, but is both much more tedious, and much less perfect, as the organization is never so thoroughly destroyed in the former as it is in the latter case. In the only exception in which the process of conversion seems equally perfect, it is limited to a small proportion of the total bulk of the material; and the pitchy matter already described as found in bogs, may be considered as a species of peat, of which the nature is completed to such a degree, as to differ but in very trifling circumstances from the pitch or bistre produced by the action of fire.

If the effects of fire in a less degree on vegetable matter be compared with those of water, the resemblance will still be apparent, as was already noticed in describing the natural solubility of peat in water. From the incipient action of fire, vegetable matter undergoes changes, by which the hydrocarbonaceous compound becomes partially soluble in water and in the other solvents of peat, while acetic acid is also generated; a portion of it being dissipated in vapour, and the remainder being soluble together with the brown matter; a circumstance very obvious in the familiar example formerly quoted, of the roasting of coffee. Some differences, it is true, are apparent, in continuing the comparison of these processes, but they do not appear difficult of explanation. Although the continued action of heat produces more acid and more of the soluble hydrocarbonaceous compound, these effects, in the operation of forming peat, diminish, or cease altogether, at a certain stage of the process. It must be considered, that the decomposition of the vegetable matter is in fact completed, as far as air and water can complete it, at an early stage, and that the remainder of the change into solid peat is rather of a mechanical than a chemical nature. The process is also far less perfect, and thus there is less acid produced; while that which is formed is carried away by the flowing of water as fast as it is generated, so as scarcely to be susceptible of examination; or is entangled in the solid peat, so as to be no longer exposed to the action of water.

Even in this case, however, long maceration and heat still extract it. Another important remark on this subject was reserved to this place. Wood-tar is highly soluble in acetic acid in all its states, and is also invariably mixed with a portion of free acid, which may be separated from it imperfectly by water, and more completely by the alkaline solutions; after either of which operations it becomes more pitchy and tenacious. When this tar, therefore, appears to dissolve in water, it is in fact partly brought into solution by the acid. It is evident how this fact operates in comparing the solubility of peat with that of wood-tar; since the dissipation and final disappearance of the acid from the former, must, in a corresponding degree, diminish the solubility of the hydrocarbonaceous compound.

It does not appear that there are at present any further means of illustrating the chemical nature of pure peat, or the nature of the effects which are produced on the matter of vegetables by the action of air and water, as far as the generation of that substance in its simple state is concerned. At this point also, the analogy between the effects of fire and of water appear to cease, since the application of the former agent has, in no direct experiment yet instituted for that purpose, produced the results which follow the ulterior action of the latter. These results are, the change from peat into lignite, through all its stages, down to the bituminization of the vegetable matter as it is found, nearly, if not absolutely, perfected in jet.

To illustrate this part of the subject, it is necessary to consider the distinction between the bituminous substances, and the hydrocarbonaceous compound which constitutes the essence of peat, and to inquire by what tests the two can be distinguished. A method of making this distinction is required for the purpose of ascertaining, if possible, the point at which the process of bituminization commences; and, by the result of the inquiry, it will be seen, that there is an essential distinction between peat and the bituminized woods, and that whatever confusion may appear between the two, follows from the admixture of both which occurs in certain states of the progress.

The comparison between bituminous wood and peat will be rendered most easy, and the actual distinctions made more striking, by selecting the simplest and extreme cases, namely, by placing in a parallel light the several bituminous substances and those products of vegetable matter already described, which are analogous to peat, and are produced by the action of fire.

It will be sufficient, in considering the bitumens, to enumerate the three most prominent varieties, namely, asphaltum, petroleum, and naphtha; the others may be considered as intermediate states or modifications of these. These substances are severally analogous to the pitch, the tar, and the essential oil of wood, and the changes which they undergo on the application of heat are in every respect similar. Thus, if petroleum be distilled, it is converted into naphtha and pitch, while the former, by a further application of heat, is decomposed, and furnishes hydrocarbonic gas. The asphaltum, by distillation, gives out petroleum, becoming gradually friable, until at length charcoal remains behind, as in the distillation of bistre. There is, moreover, in both cases, an uninterrupted transition from the essential oil to the charcoal. Thus naphtha, when of a brown colour, passes gradually into petroleum, as the oil of wood does into tar; and thus, during the prolonged distillation, both of petroleum and of tar, the oil gradually becomes thicker, while the matter in the retort, in both cases, becomes first tenacious, then brittle, and lastly friable, when a further continuance of the heat at length converts it into charcoal.

But, with this general analogy, there are important differences in the two sets of substances, united to some chemical characters common to both. There is, in the first place, a striking difference in the taste and smell, by which they can readily be distinguished; while, even the mixtures of the two, can be recognized by an union of the sensible qualities appertaining to both. These differences are most remarkable in the more fluid varieties, but are sufficiently sensible in all. The action of alcohol, of ether, acetic acid, the alkalies, and the mineral acids, on both these classes of substances, in a great measure resemble each other. Certain differences will nevertheless be found; but it is unnecessary here to enter minutely into the subject, as the detail is not required for the purposes at present in view. The most remarkable distinction in their chemical relations is the following. The essential oil of wood does not unite with naphtha, and, for this reason, while the vegetable tar and pitch are soluble in that oil, they are not soluble in the latter fluid. It produces indeed a slight effect at the boiling heat, but the dissolved portion is nearly all deposited on cooling. On the other hand, the bitumens unite readily among each other, and asphaltum is perfectly soluble in naphtha, while they refuse to unite with the oil of wood. Naphtha offers, therefore, a sort of test by which the progress of bituminization can be discovered, if not with great nicety, yet sufficiently for the purposes required.

The nature of the change by which peat is converted into bituminized vegetable matter, or lignite, will also be best understood by examining the extreme case, or by comparing the chemical composition of the bitumens with that of the products obtained from vegetables by fire. This, in the present state of chemical knowledge, can only be done in the former, as it was in the latter case, by comparing the nature and proportions of the elements, as they are obtained, either simply or in new combinations, by the action of fire. A general account only of these is here required. It thus appears, in the first place, that hydrogen and carbon form the bulk of the bituminous substances, as they do of the vegetable products, since they are chiefly converted into hydrocarbonic gas. But they yield a far inferior proportion of acetic acid, while the ammonia again appears in larger proportion; whether from its being actually present in greater quantity, or rendered more sensible by the absence of the acid, has not been ascertained. For the present purposes, it is unnecessary to inquire more minutely into this part of the subject; and it is obvious, that the essential distinction between the bitumens and the vegetable products, is the different proportions in which oxygen enters into the two. In concluding these remarks on the chemical nature of all these substances, it is only necessary to observe, that an erroneous view has been entertained of the process by which the fluid varieties are converted into the solid, in consequence of mere exposure to air. As in the case of the conversion of oil of turpentine, first into common turpentine, and then into resin, this has been imagined to arise from the absorption of oxygen from the atmosphere. The result of their decomposition, however, shows that the real change is a change of proportion between the hydrogen and carbon, which constitute the chief part of their bulk; and that the action of the atmosphere consists in dissipating, in a manner not yet understood, a portion of the former substance, so as to increase the relative quantity of carbon. It is not, in fact, dissimilar in its effects to the action of fire.

In attempting to apply this knowledge for the purpose of distinguishing peat from lignite, or of ascertaining the progress of bituminization, it will be evident, that from the identity of the products obtained by destructive distillation, and the difficulty of ascertaining minute differences in their proportions, no satisfactory results can be derived from examining these proportions, in cases where the change is incipient, where, in effect, there is a mixture of peat and bituminized matter. In the last stages, the differences become more palpable, and in the case of jet, which is the most perfect of the lignites, they are abundantly sensible. But the test of naphtha may be applied to the examination, either of the oil procured by the distillation of peat, in its progress to bituminization, or to that obtained from the lignites. By means of this fluid, the mixed oil is separated; that which is produced from the peat or unchanged vegetable matter being rejected, while that which proceeds from the bituminized vegetable matter is dissolved. A tolerable conjecture can thus be formed of the degree in which the progress of bituminization has taken place; and, when considerable, it is generally also sensible in the smell of the oil, which resembles that produced by mixing naphtha with the oil of wood. The peculiar smell which some peat gives in combustion, arises from this cause, and indicates the commencement of bituminization.

In thus examining the various kinds of submerged vegetable matter to which we have access, the progress of bituminization may be traced, with little interruption, from peat, through submerged wood, brown coal, and surturbrand, down to jet, the most perfectly bituminized substance still retaining its organization, with which we are acquainted. That which I have chosen to consider as pure peat, gives no traces of bitumen; jet, on the contrary, gives very minute indications of the products obtained from unchanged vegetable matter. The state of the submerged papyri offers an interesting example of the progress of this change, since they contain a portion of bituminous matter soluble in naphtha, and it is undoubted that they owe this change to the action of water.

If peat which has undergone a commencement of bituminization be distilled, so as to separate the oil, it will be found that this is partially soluble in naphtha. Submerged wood, according to its condition, gives similar results, the specimens sometimes yielding ordinary tar, at others a mixture of tar and petroleum. In peat, the process stops thus at the outset; but, in submerged wood, it proceeds indefinitely. Thus Bovey (brown) coal gives out a mixture of these two products, in which the petroleum bears a conspicuous proportion. The surturbrand of Sussex produces similar results; but in both these cases, different proportions of petroleum seem to be procured from different specimens, according to the varying degree to which the process of bituminization has advanced. In jet, it is difficult to ascertain whether the products differ from those which are obtained from asphaltum or from coal; but in the few trials made with this view, the proportion of acid appeared to be greater in the former than in the latter case. Should this be the fact, the bituminization, even of jet, must be considered as incomplete, and it will probably be found to yield a small proportion of tar, or of the oil of wood.

From a consideration of all these circumstances, there seems no reason to doubt that peat is a substance intermediate between common vegetable matter and bituminous lignite, and that it is capable of undergoing the ultimate change, when all the requisite conditions are present. It equally follows, that as the action of water is capable of producing the incipient change, there is no reason to doubt that it may effect the ultimate one. This is indeed confirmed by the geological situation of brown coal, of surturbrand, and of jet, all of which occur in alluvial soils. In peat, time alone seems wanting to complete the process. The history of its formation, already given, proves that it is rarely of a distant origin; and, in those cases in which it shews marks of bituminization, it will probably be found that its antiquity is the highest. The bituminous lignites are always found buried under alluvial soil, sometimes of considerable depth; a circumstance generally sufficient to indicate a longer period of exposure to the action of the cause by which the change in the vegetable compound was induced. It is probable that the peat found under alluvial soils will be more highly bituminized than when it occurs in superficial beds; as in most cases it will, in these situations, be a more ancient deposit; but as yet no opportunities for making the requisite trials have been afforded.

It is impossible, by direct experiments, to prove that water, or the action of water and air combined, is capable of changing vegetable matter into bitumen, as the necessary element of time cannot be introduced into such experiments. It may, however, be inferred, with a considerable degree of probability, from analogical observations. It has already appeared that the essential distinction between the bitumen and the products of vegetable distillation, consisted in the predominance of oxygen in the latter class of substances. Apologizing for a little laxity in the use of the term, the process of bituminization must therefore be considered as a deoxydation of the vegetable matter. Now, when turpentine is converted into resin by the action of air, or of air and water, not only the proportions of hydrogen and carbon are changed, but it no longer yields on distillation the same quantity of acetic acid. A species of deoxydation has here therefore taken place, and analogous effects appear to result from the action of the same causes on the liquid bitumens, and on vegetable tar. It was also shewn that peat yielded less acid on distillation than unchanged wood, so that the action of water in this case also, has the power of deoxydating the vegetable matter, as well as of dissipating a portion of the hydrogen which it contains. It is not unreasonable to conclude, that it may, by a continuance of the same action, produce the ultimate change into bitumen. The changes which it is capable of effecting on the fibrous parts of animal matter, by converting them into adipocire, if they do not present a very exact analogy, at least indicate a power adequate to the production of effects more complicated and less to be anticipated.

It has been asserted that vegetable matter was converted into bitumen by the action of fire; and, in extending this theory to the formation of coal, some experiments have been adduced in support of its truth *. These consisted in heating vegetable

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* Sir James Watt's experiments.

matter in close vessels, under a species of pressure which was supposed to possess a power of modifying the results to this end. But the produce in this case is neither coal nor even asphaltum, nor is it in the slightest degree bituminized. It is, in fact, the pitch or bistre, produced in the ordinary process of the destructive distillation of wood; nor could even that solid substance be obtained, unless by some careless mode of conducting the experiment, so as to suffer the more volatile products to escape. It is also certain, that the effect which fire does not produce in the commencement of its action on vegetable matter, it does not produce at any stage; and that in no case is it capable, in our hands at least, of effecting the change from those substances into bitumen.

Thus far alone does it at present appear in our power to illustrate the nature of peat, and of the bituminated lignites with which it is so nearly allied. But it would be wrong to conclude this subject without entering, however slightly, on a much more conjectural field of inquiry, namely, the possible relation of peat to coal. This is a geological question of great importance, but on which, unfortunately, there is not much real information or solid reasoning to offer.

In examining the mechanical disposition of peat-mosses and of coal, a considerable resemblance presents itself. The former occur in strata more or less extensive, as the latter do; and in both, the strata vary in thickness in different parts, commonly disappearing in a thin edge. Strata of peat are also occasionally found, like coal strata, repeated above each other in the same place, and separated by beds of sand, clay, and marl; substances corresponding, in every respect but induration, to the sandstone, shale, and limestone of coal-fields. In both also, there are occasionally found remains of animals and vegetables, of which the organization is not destroyed; and this is most remarkable in the peat of estuaries, where these have been entangled in the earthy matters as they are in the shale of coal-fields. Where peat has been formed in lakes or extensive marshy cavities, it occupies distinct spots, separated from others of the same nature, as are those deposits of coal which have been called Independent Formations.

The resemblance in composition between peat and coal is equally remarkable. In many coal strata, as in certain kinds of peat, no remains of organic materials can be detected. In others, remains of various plants are found, and these, as in peat, present botanical characters which indicate an aquatic origin. In some, fragments of wood abound, and the specimens of this nature bear a striking resemblance to the peat of forests. But this subject is trite, since it has been a frequent subject of remark.

The chemical differences between peat and coal are unquestionably great, as are the mechanical differences of texture and compactness; but it must be presupposed that the comparison is here to be drawn between a stratum of peat previously bituminized, and in which the change has been completed, even to a degree beyond that of jet. In this case, the chemical distinction ceases, and it remains only to account for the mechanical differences of compactness, and of a peculiar structure, analogous to that of shale, by which coal is distinguished from all the bitumens and bituminated lignites.

As it is here said that the chemical distinction between coal and lignite ceases at the period of complete bituminization, it is necessary to state more accurately what the real distinctions are between coal, asphaltum, and the bituminous lignites; all of these being substances which give results on distillation that correspond in a very perfect manner.

The composition of asphaltum, as it is commonly found in nature or produced by art, differs chiefly from that of coal in its containing a smaller proportion of carbon to the hydrogen, or in its yielding on distillation a greater quantity of petroleum, and a smaller quantity of residual charcoal. But even between these two substances there is sometimes no such distinction, or it is very trifling; as very dry varieties of asphaltum will be found to contain as much charcoal as the fat or bituminous varieties of coal. The chief distinction, at all times, appears, as already suggested, rather of a mechanical nature; or, it is a difference of structure by which coal is chiefly distinguished from asphaltum. It is not difficult to conjecture how that difference has originated, as the coal has been apparently bituminized directly from the vegetable matter, while the asphaltum having once been liquid, its charcoal has originally been in a state of chemical combination with the hydrogen.

Between the chemical composition of coal and lignite, supposing the latter perfectly bituminized, there appears no difference; the only sensible one being that arising from the remains of organization visible in the latter. By a process of fusion, jet can in fact be converted into coal; or, at least, the slight difference which may remain, is that only which arises from the imperfect bituminization of the jet; a circumstance which does not affect this inquiry.

It remains, therefore, only to discover by what process beds of bituminized peat or lignite may have been so condensed as to acquire the peculiar compactness and mineral structure displayed by coal; as the chemical resemblance has been established, and as it has been shewn that the former are produced by the action of water on vegetable matter. Those who have considered the process of bituminization to have resulted from the action of fire, have also viewed the peculiar structure of coal as the consequence of fusion under pressure. The fallacy of the experiments by which the former circumstance was supposed to be established, has already been shewn. To determine the probability of the latter supposition by a more correct mode of experimenting, portions of jet were submitted to the action of fire, under pressure so regulated as to admit the escape of such volatile matter as might endanger the apparatus. Thus the organized structure of the jet was destroyed, and the mass was brought into fusion. On being cooled, it broke easily into irregular fragments, not unlike some varieties of coal. In all other respects, as might be expected, it bore an exact resemblance to that substance; and it is also worthy of remark, that in proportion to the greater or less facility with which the volatile matter escaped, the results bore an analogy, sometimes to dry, and at others to bituminous coal.

It does not, however, follow from these experiments, that the theory which they seem to support is the true one. There is, in the first place, a deficiency of evidence to prove, that the secondary strata in which coal is found have been exposed to the action of fire. In the next place, although the superincumbent weight of materials would undoubtedly give the degree of pressure required by this hypothesis, that pressure is not in itself sufficient to answer all the required conditions. The porosity of the strata which surround coal, is generally such that they would not prevent the escape of the volatile matters which would be separated by the action of fire. The coal would therefore be charred in a great proportion of cases, while the surrounding materials would be impregnated with bitumen. That the former effect would take place, is proved by an occurrence by no means unfrequent, which may be considered as a direct experiment in illustration of this question, performed by nature on the great scale. This occurrence is the passage of trap-veins through beds of coal, the effect of which is to produce the consequences in question, notwithstanding the pressure of the superincumbent strata. The frequent occurrence of bituminous shale, or of bituminous sandstone in the vicinity of coal, admits of an easy explanation, without the necessity of recurring to the action of fire; by recollecting that the mixture of peat with clay and with sand, which is not unfrequent, would necessarily be converted into these compounds by the same causes which changed the pure peat into coal. Lastly, it is not possible to conceive, that had coal been produced by the fusion of peat or lignite, the forms of vegetables should have so often been preserved; since, in applying artificial heat, even under pressure, all marks of organization are obliterated; a consequence that might indeed be easily foreseen.

There appears no reason, therefore, to attribute the peculiar form and structure of coal to the action of fire, but the supposition is, on the contrary, attended by unsurmountable difficulties. On the other hand, there appears no difficulty in conceiving that these may have resulted from mere pressure. Jet and brown coal are unquestionably indebted to this for their compactness and form; and there is scarcely a greater difference in this respect between coal and compact peat, than there is between jet and common submerged wood. Nor is it very difficult to conceive that, under a state of minute division, aided possibly by the presence of water, coal might assume the peculiar mineral structure by which it is characterised. Under similar circumstances, shale appears to be produced from clay, and there is a striking analogy between the concretionary structure of this rock and that of coal.

With respect to the comparative position of peat and of coal, as they relate to the earth's surface, they present no difficulty which is not easily removed by geological analogies. The difference depends solely on their relative antiquity, and it is no more difficult to imagine beds of peat deposited under the materials which have been converted into rocks, than to account for beds of conchiferous limestone, or for the accumulations of organic remains, both animal and vegetable, which are found deeply buried beneath the rocky strata of later origin.

Art. II.—*Account of the Seven Icebergs of Spitzbergen**. By William Scoresby, Esq. jun. F. R. S. E. and M. W. S. &c.

One of the most interesting appearances to be found in Spitzbergen, is the Iceberg. This term, written *Ysberg* by the Dutch, signifies ice-mountain. I speak not here of the islands of ice which are borne to southern climates on the bosom of the ocean, but of those prodigious lodgments of ice which occur in the valleys adjoining the coast of Spitzbergen and other Polar countries, from which the floating icebergs seem to be derived. Where a chain of hills lies parallel to the line of the coast, and within a few miles distance of the sea-beach, having lateral ridges jutting towards the sea, at intervals of a league or two, we have a most favourable situation for the formation of icebergs. Such is precisely the nature of the situation a little to the northward of Charles' Island, where the conspicuous bodies of ice noticed by Martens, Phipps and others, and known by the name of the *Seven Icebergs*, occur. Each of these occupies a deep valley, open towards the sea, formed by hills of about 2000 feet elevation on the sides, and terminated in the interior by the chain of mountains, of perhaps 3000 to 3500 feet in height, which follows the line of the coast. They are exactly of the nature and appearance of glaciers; they commence at the margin of the sea, where they frequently constitute a considerable precipice, and extend along the valley, which commonly rises with a gentle slope, until they are either terminated by the brow of the mountain in the back ground, or interrupted by a precipitous summit. Besides these icebergs, there are some, equally large, near the north-west angle of Spitzbergen, in King's Bay and in Cross Bay, and some of much greater magnitude near Point-look-out, besides many others of various sizes, in the large sounds on the western side, and along the northern and eastern shores of this remarkable country.

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* Taken, with the author's permission, from his work on the Arctic Regions, vol. i. p. 101.—Ed.

The Seven Icebergs are each, on an average, about a mile in length, and perhaps near 200 feet in height at the sea edge; but some of those to the southward are much greater. A litttle to the northward of Horn Sound, is the largest iceberg I have seen. It occupies eleven miles in length, of the sea-coast. The highest part of the precipitous front adjoining the sea is, by measurement, 402 feet, and it extends backward toward the summit of the mountain, to about four times that elevation. Its surface forms a beautiful inclined plane of smooth snow; the edge is uneven and perpendicular. At the distance of fifteen miles, the front-edge subtended an angle of ten minutes of a degree. Near the South Cape lies another iceberg, nearly as extensive as this. It occupies the space between two lateral ridges of hills, and reaches the very summit of the mountain, in the back-ground, on which it rests.

It is not easy to form an adequate conception of these truly wonderful productions of Nature. Their magnitude, their beauty, and the contrast they form with the gloomy rocks around, produce sensations of lively interest. Their upper surfaces are generally concave; the higher parts are always covered with snow, and have a beautiful appearance; but the lower parts, in the latter end of every summer, present a bare surface of ice. The front of each, which varies in height from the level of the ocean, to 400 or 500 feet above it, lies parallel with the shore, and is generally washed by the sea. This part, resting on the strand, is undermined to such an extent by the sea, when in any way turbulent, that immense masses, loosened by the freezing of water lodged in the recesses in winter, or by the effect of streams of water running over its surface and through its chasms in summer, break asunder, and with a thundering noise fall into the sea. But as the water is in most places shallow in the front of these icebergs, the masses which are dislodged are commonly reduced into fragments before they can be floated away into the main sea. This fact seems to account for the rarity of icebergs in the Spitzbergen sea.

The front surface of icebergs is glistening and uneven. Where-ever a part has recently broken off, the colour of the fresh fracture is a beautiful greenish-blue, approaching to emerald-green; but such parts as have long been exposed to the air, are of a greenish-grey colour, and at a distance sometimes exhibit the appearance of cliffs of whitish marble. In all cases, the effect of the iceberg is to form a pleasing variety in prospect, with the magnificence of the encompassing snow-clad mountains, which, as they recede from the eye, seem to "rise crag above crag," in endless perspective.

On an excursion to one of the Seven Icebergs in July 1818, I was particularly fortunate in witnessing one of the grandest effects which these Polar glaciers ever present. A strong north-westerly swell having for some hours been beating on the shore, had loosened a number of fragments attached to the iceberg, and various heaps of broken ice denoted recent shoots of the sea-ward edge. As we rowed towards it with a view of proceeding close to its base, I observed a few little pieces fall from the top, and while my eye was fixed upon the place, an immense column, probably fifty feet square, and one hundred and fifty feet high, began to leave the parent ice at the top, and leaning majestically forward, with an accelerated velocity fell with an awful crash into the sea. The water into which it plunged was converted into an appearance of vapour or smoke, like that from a furious cannonading. The noise was equal to that of thunder, which it nearly resembled. The column which fell was nearly square, and in magnitude resembled a church. It broke into thousands of pieces. This circumstance was a happy caution; for we might inadvertently have gone to the very base of the icy cliff, from whence masses of considerable magnitude were continually breaking. This iceberg was full of rents, as high as any of our people ascended upon it, extending in a direction perpendicularly downward, and dividing it into innumerable columns. The surface was very uneven, being furrowed and cracked all over. This roughness appeared to be occasioned by the melting of the snow, some streams of water being seen running over the surface; and others, having worn away the superficial ice, could still be heard pursuing their course through sub-glacial channels to the front of the iceberg, where, in transparent streams, or in small cascades, they fell into the sea. In some places, chasms of several yards in width were seen, in others they were only a few inches or feet across. One of the sailors who attempted to walk across the iceberg, imprudently stept into a narrow chasm filled up with snow to the general level. He instantly plunged up to his shoulders, and might, but for the sudden extension of his arms, have been buried in the gulf.

In the first ages of the Spitzbergen fishery, when the ships frequented the bays and harbours, and sometimes moored close to the shore, many serious disasters were occasioned by the fall of pieces of icebergs. An instance is recorded by PURCHAS in his "Pilgrimes." One of the Russia Company's ships, which was on the whale-fishery in the year 1619, was driven on shore in Bell Sound, by ice setting in from the sea. The Captain, with most of his crew and boats, was absent at the time of the accident; but on the first intelligence, caused his boats to be hauled up on the ice, and proceeded on board to endeavour to get the ship off. After they had been using every endeavour for this purpose during about an hour, a main piece of an adjoining ice-cliff came down, and almost overwhelmed the vessel and her crew in its ruins. The shock must have been tremendous. The ice which fell, struck the ship so high and so forcibly, that it carried away the foremast, "broke the main-mast," sprung the bowsprit, and flung the ship over with such violence, that a piece of ordnance was thrown overboard from under the half-deck; and the Captain and some of the crew were projected in the same way. The Captain, notwithstanding his imminent danger, with fragments of ice flying in all directions, and the masts of the ship falling around him, escaped unhurt; but the mate, and two more of the crew, were killed, and many others were wounded.

Icebergs are probably formed of more solid ice than glaciers; but in every other respect they are very similar. The ice of which they consist is, indeed, a little porous; but considerable pieces are found of perfect transparency. Being wholly produced from rain or snow, the water is necessarily potable. Icebergs have also the same kind of origin as glaciers. The time of their foundation, or first stratum being frozen, is probably nearly coeval with the land on which they are lodged. Their subsequent increase seems to have been produced by the congelation of the sleet of summer or autumn, and of the bed of snow annually accumulated in winter, which, being partly dissolved by the summer sun, becomes consolidated; and, on the decline of the summer heat, frozen into a new stratum of transparent ice. Snow subjected by a gentle heat to a thawing process, is first converted into large grains of ice, and these are united, and afterwards consolidated, under particular circumstances, by the water which filters through among them. If, when this imperfectly congealed mass has got cooled down below the freezing temperature by an interval of cold weather, the sun break out and operate on the other surface so as to dissolve it, the water which results runs into the porous mass, progressively fills the cavities, and being then exposed to an internal temperature sufficiently low, freezes the whole into a solid body. Or if, when the ice has been cooled by a low temperature, a fog or sleet occur, it is frozen as it falls, and encrusts the body of the iceberg with an additional varnish of ice.

Icebergs are as permanent as the rocks on which they rest; for though large portions may be frequently separated from the lower edge, or, by large avalanches from the mountain summit, be hurled into the sea, yet the annual growth replenishes the loss, and, probably, on the whole, produces a perpetual increase. But the annual supply of ice is not only added to the upper part, but also to the precipitous crest facing the sea; which addition being run into, or suspended over the ocean, admits of new fragments being detached, and of the renewal of the vitreous surface which it presents to the eye after each separation. In some places, indeed, where the sea is almost perpetually covered with ice, the berg or glacier makes its way to a great extent into the sea, until it reaches the depth in the water, of several hundreds of feet; and then being capable of large dismemberments, gives rise to the kind of mountainous masses or icebergs, found afloat in such abundance in the sea to the westward of Greenland. Thus, the extent of surface occupied by each iceberg, is limited by the mountains on three sides, and by the sea, in a measure, on the fourth; but as to its thickness, there seems no natural obstacle to its perpetual increase.

ART. III.—*Account of the Malleable Iron Passage-Boat, now plying on the Forth and Clyde Canal.* In a Letter from JOHN ROBISON, Esq. F. R. S. E. to Dr Brewster.

DEAR SIR, *The Grove, December* 1819.

I HAVE now the pleasure of sending you the memoranda and sketches you wished for, of the malleable iron passage-vessel, constructed last winter and spring for the service of the Forth and Clyde Canal Company, by Mr Wilson, ship-builder, from the designs, and under the direction of a very able engineer, Mr Henry Creighton, late of Soho, and now of Glasgow.

The Hull was built of iron, in order to avoid the often recurring and expensive repairs to which the wooden vessels had been found liable. Considerable opposition to the plan was made by the persons connected with the navigation of the boats, who said it would be found inconvenient and unfit for the service; but experience has proved it otherwise, and *The Vulcan* has been found to be the most agreeable and manageable of the passage-vessels in every variety of weather, while, though carrying more passengers than any on the old plan, it is as easily tracked as the smallest of them; and from the lowness of the centre of gravity, it admits of a large cabin and awning on deck, where the passengers are better accommodated than in the former way below. The dimensions are,

Extreme length, - - - -	63 feet,
Beam, - - - - - - - -	13
Depth, (including 5 inches keel)	5

	Abaft.	Forward.
Draft of water of the iron hull, when launched, - - - - - - - - - -	22 inches,	19 inches.
Ditto, when fitted up with cabins, &c., - - - - - - - - - -	37	25
Ditto, with 200 passengers and their luggage, -	under 48 on an even keel.	

PLATE VII.

Fig. 1.

MALLEABLE IRON PASSAGE BOAT.

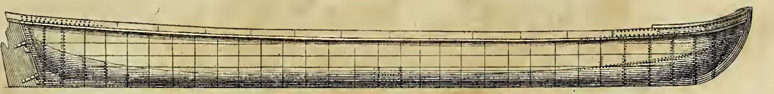
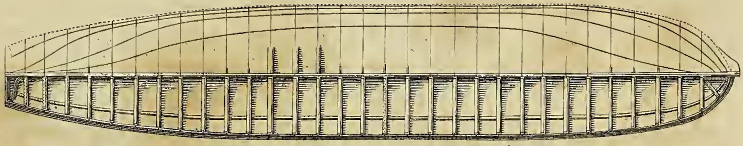
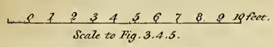


Fig. 2.





Scale to Fig. 3. 4. 5.

Fig. 3.

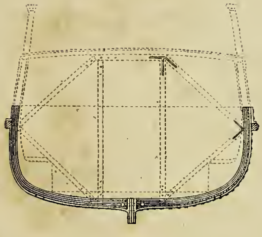


Fig. 4.

STERN.

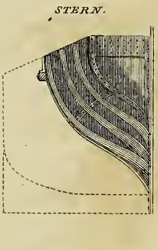


Fig. 5.

BOW.

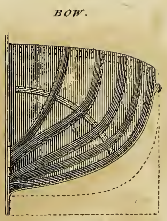
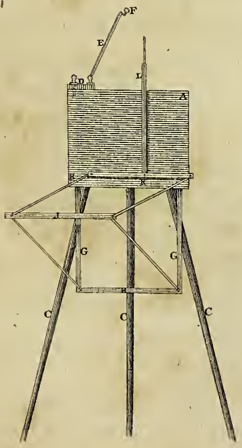


Fig. 7.



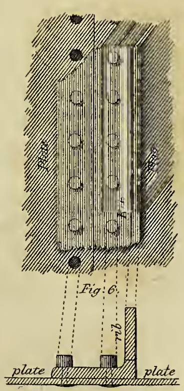
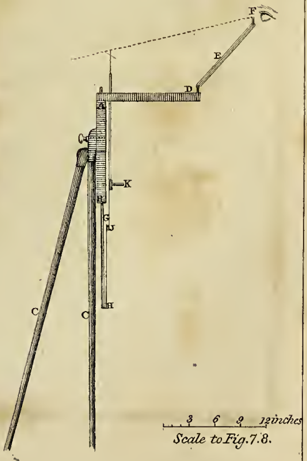


Fig. 8.



Scale to Fig. 7. 8.

Fig. 1 to 6. Drawn by H. Creighton, Esq.

Archibald Sculp.

Published by A. Constable & Co. Edinr. 1820.

Weight of iron employed *.

	Tons.	Cwt.	Qrs.
Keel, stem and stern-posts, - -	1	18	0
Ribs, rivets, &c. - - - - - - -	4	0	0
Plates for the body, - - - - - -	5	0	0
Gunwale-plates, - - - - - - -	1	2	0
Rudder, bilge-plates, &c., - - -	0	11	3
	12	11	3 at 54 per cwt.

or little more than twelve and a half tons, which is rather less than that of a wooden vessel of the same external, and smaller internal dimensions.

The accompanying sketches shew the modes of joining and fastening so distinctly, that I need not trouble you with any detail.

Plate VII. Fig. 1.	is a broadside view,	on a small scale
2.	a bird's-eye view of half the inside, (termed a half breadth plan,)	
3.	a midship section,	on a larger scale.
4.	part of the inside, (looking aft,) - -	
5.	Do. do. forward, -	
6.	a small part of a rib and plates, (much enlarged.)	

This mode of joining the plates edge to edge without overlapping, and having the rivet-holes counter sunk on the outside, gives a perfectly smooth surface, which, when painted, cannot be distinguished from that of wood plank.

The sketches are taken from the original plan for a boat of 11 feet beam; in the execution it was enlarged to 13 feet.

An unforeseen advantage has been experienced in the use of this vessel, the cause of which is not very apparent. When any of the other boats have been laid alongside of the canal bank to take in or discharge passengers, they continue, on being again put in motion, to rub on the bank, until they acquire

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* The iron was of the kind called *Scrap*, and was rolled and forged at the Monkland Steel Company's Works.

head-way enough to bring them under command of the rudder, but the Vulcan immediately *springs* off the bank, and takes into the middle of the canal *.

Pumps for clearing away leakage or bilge water were put into her, but I believe they have hardly been required to be used.

It has been under contemplation to cause the horses to track the boats through the intervention of a spring, in order to equalize their exertions, which vary, in *very minute portions of time*, from 100 lb. to 1000 lb. while the average strain on the line is between 250 lb. and 300 lb. It has been found impracticable, however, to procure springs combining sufficient power of extension † and strength, and I believe we must have recourse to one whose temper will not be found liable to fail; I mean that of air acted on by a piston in a barrel of adequate dimensions. Perhaps some of your readers will have the goodness to suggest a convenient form. The points to be observed are, that the apparatus do not incommode the passengers, and that it be adapted to the use of such people as are employed in navigating the vessels. I remain, my dear Sir, very sincerely yours,

JOHN ROBISON.

ART. IV.—*Sketch of the Distribution of Rocks in Shetland.*

By SAMUEL HIBBERT, M. D. F. R. S. E. and M. W. S. &c.

(Concluded from p. 79.)

ROCKS IN THE WESTERN DISTRICTS OF SHETLAND, COMPRISING THE PARISHES OF SANDSTING, WALLS, AND AITHSTING.

THE whole of these rocks are situated to the west of that extreme portion of the mass of epidotic sienite, which we may trace from Sand Voe, in a northerly direction, to Aith Voe. The rocks of this district may be thus enumerated: they are, 1*st*, The granite of Sandsting; 2*dly*, The strata maintaining a course from the granite of Sandsting, to that part of the epidotic sienite which extends from Sand Voe to Aith Voe; *3dly*, The bluish-grey quartz of Walls and Aithsting; *4thly*, The strata maintaining a course from the granite of Sandsting, to the bluish-grey quartz of Walls and Aithsting; *5thly*, The strata maintaining a course from the bluish-grey quartz of Walls and Aithsting, to the granite of the Islands of Vementry and Meikle Rheu; *6thly*, The red quartz of the Hill of Walls; *7thly*, The strata maintaining a course from the red quartz of the Hill of Walls in a northerly direction, their supposed junction with the granite of Meikle Rheu being concealed by the sea; *8thly*, The sandstone, porphyritic claystone, conglomerate and amygdaloidal rocks of Sand Ness, and the Island of Papa Stour.

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* The form of the bottom of this boat was copied from a model sent by Admiral Shank. It excels the others which have been tried, as it occasions little agitation in the water, and is therefore favourable to the preservation of the Canal banks.

† It is wished that the extension should not be less than three feet, with the force of 1000 lbs.

1*st*, *The Granite of Sandsting.*—I have thus designated the rock from the parish in which it occurs. The granite is composed of a very red felspar and quartz, containing little or no mica. Hornblende is occasionally an abundant ingredient, by the acquisition of which we have a sienitic rather than a granitic rock. This mass, which is what geologists call wedge-shaped, displays, in a horizontal section, a truly crystalline appearance. The two bounding lines of this wedge-shaped mass, appear to diverge from a mere point at the head of Bixetter Voe. The westerly line may be traced in a direction of S. 35° W. where it is in contact with the quartz last described, to Valey Island. The easterly line may be observed in a direction of nearly due south to pass through Rewick in Skelda Voe, terminating on the east of Skelda Ness.

2dly, Strata maintaining a course from the Granite of Sandsting to that part of the Epidotic Sienite which extends from Sand Voe to Aith Voe.—These strata, in tracing them from the south, are first manifested at Rewick Ness, where their actual junction with the granite at Skelda Ness is only concealed by the intervention of the narrow channel of Skelda Voe. From Rewick Ness the strata are continued to the Island of Kirkholm and to Kirkaness, situated between Selie Voe and Sand Voe, and, lastly, to Bixeter Voe, where they are observed to be in junction with the epidotic sienite. Thus, the course of the strata is from the granite of Sandsting to the epidotic sienite.

I find that it will be difficult under one single term, to convey any significant idea of the ingredients of which the rocks of Rewick Ness and Kirkaness are composed. A white quartz, generally compact, is certainly one of the component parts, which is the most prevalent; but this is blended with talc, or with mica, which approaches much to the character of talc, and also with felspar. The term I shall use to express this combination will therefore be, "a quartzose rock combined with talc, mica, and felspar." The rock is particularly prone to decomposition, so that it is difficult to obtain a specimen that is not weathered. The stratification is very much confused, and often obscure. The best directions which I could obtain were from N. 15° to 20° E. which is agreeable to the particular course of the strata already stated. These also vary much from the interruption caused by small insulated masses of granite, as well as by the occasional association of the quartzose rock with hornblende-slate. Several masses of limestone are also apparent, which have a course nearly parallel to that of the strata among which they occur; of these, the most considerable is in the Island of Kirkholm. Limestone also occurs at Kirkaness, and on the shores of Bixeter Voe.

To the west of the quartzose strata at the head of Selie Voe, and on its western banks, is a subordinate manifestation of those kinds of rocks which I have described under the character of nuclei, as affording attachments to strata, as well as determining their course and extent. This small bounding mass is a confused intermixture of hornblende, greenstone, granite, felspar-porphyry, and sienite, together with occasional strata of clay-slate, the whole being in a very loose state of decomposition. This miscellaneous rock has probably, with the exception of the clay-slate, the effect of affording attachments to other quartzose strata, which, though very considerable as to their extent, may be traced north of Bixeter Voe, as far as Aith Voe, in junction with the epidotic sienite.

3dly, The Bluish-grey Quartz of Walls and Aithsting.—This mass may be also, like the granite of Sandsting, considered as wedge-shaped, and is best traced from north-east to south-west. In a horizontal section, its form seems no less crystalline than that of the granite. Two bounding lines appear to diverge from nearly a point in the Island of Papa Little, of which the one is continued in a direction of S. 60° W. to the western coast, a little north of the village of Dale; whilst the other extends in a straight line S. 32° W. to the head of Bixeter Voe, when it first comes in contact with the granite of Sandsting, and thence is continued, in the same direction, to Valey Island.

The quartz is distinguished in colour from that of an adjoining mass of a similar kind, by being bluish-grey, and it is variously found with a compact and granular structure. It admits into its composition much felspar, which is rendered very evident in weathered specimens, containing also, in addition to the felspar, occasional small portions of clayslate, by which it becomes the Grauwacke of some authors. Along its north-westerly line of boundary from Papa Little to Kilista Voe, the quartz is porphyritic, including, besides crystals of felspar, angular portions of the same, which give to the rock on this occasion somewhat of a conglomerated character. At Valey Island and Gruting Voe, and along the line where the quartz is joined to the granite of Sandsting, either an alternation of the two rocks, or a transition of one rock into another, by an interchange of substance, frequently takes place. Occasionally, however, none of these appearances are manifested, and the line of junction is perfectly distinct.

The stratification of the quartz is only an occasional circumstance, which seems remarkably connected with the partial occurrence of mica. Wherever regular strata are thus produced, they range with those of no other contiguous rock, the direction being nearly from east to west. Considering, therefore, this independency of stratification, together with the crystalline form of the quartz, as it appears in a horizontal section, I have little hesitation in assigning to it the character of a nucleus. That it appears to determine the extent and direction of strata in the attachments which it affords to them, will be rendered evident when I treat of the rocks in connection with it.

At the North Voe of Clousta, there occurs, resting on the quartz, a small roundish conglomerated mass of granite, felspar, and quartz, scarcely, perhaps, more than 150 yards in diameter. Such a gradual transition of one rock into the other is observable at the junction, as to assign to each a cotemporaneous origin. A few of the conglomerate strata next to those of the quartz, range with them at a similar angle of 45°. But, crossing the strata for a distance of a few yards only, they gradually acquire an inclination with the horizon of only 10°, and, maintaining this position, they are terminated. Now, there is every reason to suppose, that the lower edges of the strata of the conglomerate rock, are in contact with the surface formed by the upper edges of the strata of quartz, in the manner of other conglomerate strata formerly described. This change of inclination, therefore, from 45° to 10°, can be satisfactorily accounted for, on the supposition, that the strata had acquired an addition of new matter in their descent; which addition may either consist in an increased thickness of the strata, or in an accession of new strata. It is thus that the increased accumulation of matter, which the strata may possibly have received in proportion to their depth, would produce an elevation of the uppermost strata.

4thly, The Strata maintaining a Course from the Granite of Sandsting to the Bluish-grey Quartz of Walls and Aithsting.—An angular space, formed by the easterly bounding line of the granite, which obliquely meets that of the quartz, is distinguished by the presence of gneiss. This space includes the land to the west of Selie Voe, with the exception of Rewick Ness, and also the land to the north-west of Selie Voe, and south of Bixeter Voe; together with that tract which lies between the north of Bixeter Voe and the small hill of Braewick, to the west of Aith Voe.

These strata are first observed on an eminence to the west of Selie Voe, where they are separated from the quartzose strata of Kirkaness, by the intervention of the miscellaneous rock already described, which is of little extent, consisting of hornblende, greenstone, granite, felspar-porphyry, and sienite; together with occasional strata of clay-slate. The rocks in all the track south of Bixeter Voe, are so concealed by a deep bed of turf, that we must depend upon a very few occasional exposures for the removal of our difficulties with regard to the nature of the strata. But to the north of Bixeter Voe, and to the west of Aith Voe, the rocks are somewhat better exposed. The gneiss is occasionally associated with mica-slate, and is traversed by insulated veins of granite. From the very few opportunities afforded me to judge of the direction of the strata, they appeared to run about N. 12° E. The dip was to the west at a variety of angles, generally about 45°.

5thly, The Strata maintaining a Course from the Bluish-grey Quartz of Walls and Aithsting, to the Granite of the Islands of Vementry and Meikle Rheu.—In reference to the course of these strata, I am obliged to anticipate that a very considerable mass of granite occupies the north-west portion of Shetland, which, in tracing it from the south, is first observed in that northerly part of the Island of Vementry, which is contained between the Northern Voe on the west, and a small inlet of the sea on the east, close to the house of Mr Dixon. This mass is continued to the adjoining Island of Meikle Rheu, and thence to the parish of Northmavine in the Mainland. I shall have occasion to describe hereafter this mass of granite, which, in its mineralogical character, resembles in a great measure that of Sandsting.

The strata now under consideration derive their course, as we trace them in a northerly direction, from that part of the bounding line of the bluish-grey quartz, which has been described as passing into porphyry, and which may be geographically pointed out as including the north-westerly angle of the Island of Papa Little, the Island of Vementry, with the exception of that part which is occupied by the granite, the tract of land south of Uyea Sound lying between Braganess and Sonsoness, the extremity of the Ness of Nunsburgh, the promontory of the Neing, and the south bank of Burra Voe, where it joins the headland of Snarraness.

The strata consist of gneiss, so associated, however, and intimately combined with hornblende, that I have given to the rock the name of Hornblendic Gneiss. In every specimen which we examine, the hornblende is either openly manifested, or is in such a state of intimate union with the felspar, as to impart to this ingredient of the rock a greenish tinge. Innumerable small insulated masses of granite also are every where present, traversing the strata in all directions; whilst, occasionally, in the place of granite, we observe felspar-porphyry, sienite or sienitic greenstone. Several masses of limestone also, of inconsiderable extent, maintain a course nearly parallel to that of the adjoining strata. A thin stratum of limestone is observed near Sonsoness to penetrate a small mass of granite, its course through the rock being in a very remarkably degree distorted. There is, at the same time, an intermixture of the substances of which both rocks are composed.

It is owing to the general presence of those small insulated masses to which the character of nuclei has been assigned, that it would be very difficult to speak with much degree of accuracy, respecting the general direction or dip of the strata among which such interrupting masses occur. The most prevalent direction seemed to be from N. to N. 45° E. The actual course of the strata, however, considered *en masse*, is certainly from the bluish-grey quartz of Walls and Aithsting, to the granite of Vementry and Meikle Rheu. The junction of the quartz with the strata of gneiss, is perceptible throughout nearly the whole line of boundary described; but the junction of the gneiss with the granitic mass to the north, is only manifested in the Island of Vementry; elsewhere, it is concealed by the approach of the sea. In Vementry may be observed a few very remarkable invasions of the gneiss, by processes from the mass of granite. In the promontory of the Neing, also, there is probably a similar invasion from the granite of Meikle Rheu; for to such a connection, though concealed by the sea, may perhaps be referred the penetration of the strata of gneiss, by a veinous mass measuring 45 feet in width.

6thly, The Red Quartz-Rock of the Hill of Walls.—The bluish-grey quartz before described, is connected in its northern boundary line with another but smaller mass of quartz, the colour of which is, according to Werner's nomenclature, cochineal red. The red quartz also contains felspar in its composition; it is at the same time unstratified. The rock may be geographically described, as forming the hill of Walls, having an elevation of nearly 1200 feet above the level of the sea. The form of this mass of red quartz, as induced by a horizontal section, is very nearly similar to that of the bluish-grey quartz. There is only this difference, that, in the red quartz, the angular apex from which the divergency of its bounding lines is continued, is bent outwards so as to be separated from the bluish-grey quartz to which the rock is elsewhere joined. This apex of the red quartz, geographically represented by Snaraness, together with its separation from the contiguous mass of bluish-grey quartz, may be easily detected by observations made at the point of land to which I refer, on the east of Kilista Voe.

7thly, The strata maintaining a course from the Red Quartz of the Hill of Walls, their supposed junction with the Granite of Meikle Rheu being concealed by the Sea.—These strata which line the coast, occupy all the space in the map, bounded on the east by Snaraness, and on the west by the Cliffs to the east of the harbour at Norbie.

Almost every thing that has been said relating to the last mentioned strata, will apply to the description of the present rocks. Exclusively of certain rocks near Busta Voe, which consist of gneiss associated with little or no hornblende, and of certain strata of gneiss to the east of Norbie, which are distinguished by the excess of quartz which they contain;—with these exceptions, the strata may be considered as coming under the character which I have given of hornblendic gneiss. They are traversed in the same manner by innumerable small insulated masses of granite; they are occasionally diversified by the presence of parallel strata of limestone, particularly near Busta, and the direction and dip of the strata is, from such alleged causes, greatly confused. However, a distinct line of bearing may not unfrequently be detected to the north-east, and since the strata of gneiss, as we trace them from the south, derive their course from the red quartz, such a derivation being evident throughout the whole bounding line of the quartz, they are probably, in the channel of the ocean, intercepted by the contiguous mass of granite in the Island of Meikle Rheu. But it is needless to add, that such an alleged termination of the course of these strata, which their contiguity to the granite mass, conjoined with the line of direction in the strata renders very probable, can, in the absence of palpable evidence, be only offered as mere conjecture.

8thly, The Sandstone, Porphyritic Claystone, Conglomerate and Amygdaloidal Rocks of Sandness, and the Island of Papa Stour.—At Eastgio, west of the coast of Walls, may be first observed, as we trace it from the south, a mass of sandstone or granular quartz, the eastern boundary of which may be traced from its junction with the red quartz of the Hill of Walls, along the coast as far as the House of Melby and to the Holm of Sandness. The sandstone differs from the red quartz, by containing less felspar, by possessing a structure more granular and less hard, and by the general whiteness of its colour. The direction of the strata is generally about N. 55° E., the dip being to the east under an angle of 45° ; frequently, however, a much less inclination is observable. Near Eastgio, the sandstone is associated with strata of clay-slate, almost horizontal, and, near the House of Melby, with claystone porphyry of a conglomerate structure.

As we approach the shores of Papa Stour, the sandstone ceasing to become the prevalent rock, we observe the island to be chiefly composed of felspar-porphyry. This rock admits of several varieties. Of these, the first is found chiefly on the south-east of the island near North-house: it contains a great excess of felspar, but is slightly porphyritic; the colour of the rock is brick-red. The second variety, occurring on the north and north-east, also occasionally on the south of the island, is denoted by a greater quantity of argillaceous matter, which being of a deep reddish-brown colour, and unequally combined with red and reddish-white felspar, often gives the rock a variegated appearance. The third variety differs little from the other, except in being less variegated, and in the greater number of its crystals of felspar. It is to be found on the south-west and west of the island.

The claystone porphyry, which is generally, in Papa Stour, an unstratified rock, may, in reference to the varieties which it exhibits, be resolvable into several distinct masses, the bounding sides of which not coming into mutual contact, their intervening spaces are supplied by strata. In other instances, the strata appear to merely fill up those concavities of the porphyry which are of a subordinate depth. Rejecting, then, any mechanical notion which would refer the intervention of strata between the rocks, or the filling up of inequalities, to the circumstance of one stratum in a series regularly reposing upon another, as if rocks were the result of a number of successive deposits, I have, on the contrary, been rather disposed to compare strata to certain crystalline laminæ, which variously attach themselves by their edges to the sides of nuclei. Adopting this view, we are then entitled to expect that strata attached to certain sides of the claystone-porphyry as to nuclei, will not always preserve in their connection one uniform horizontal or inclined position: On the contrary, agreeably to the appearances presented at Papa Stour, strata of various dimensions and thickness will often meet the rocks, affording attachment to their edges, in every imaginable circumstance of variation and disorder.

I shall now commence my examination of the strata of Papa Stour at the most southerly part of the island, which is east of Hamna Voe, at the Point of Bragaster. Here a large mass of claystone-porphyry is distinctly observed to come in contact with a surface formed by the superior edges or outgoings of strata of sandstone. And since these strata contain no fragments of other rocks, being, with the exception of their very red colour, similar to the rock of the same name at Sandness, I was inclined to suspect that many, or perhaps the whole, of the masses of claystone-porphyry might be superimposed on a surface of sandstone. But, on the contrary, there is no evidence to shew, that the part in contact with the sandstone may not belong to the deep *impendent side* rather than to the *under* surface of the porphyritic mass; consequently, the relations of the under surface of the unstratified rock may be perfectly unknown: Or, again, that part of the porphyry in contact with the sandstone, may belong to a small portion only of the under surface of the superimposed mass. The rest of the under surface may be in contact with rocks of a very different description. Thus, the Voe Skerries lying to the north-west of Papa Stour, and the rocks of Norbie, situated to the south-east, are all composed of hornblendic gneiss; and when we take into consideration the detached fragments of hornblende, and slaty actynolite, abundantly found in the island, either a part or the whole of the rocks of Papa Stour may, for any thing that can be proved to the contrary, rest upon a surface formed by the outgoings or upper edges of strata composed of hornblendic gneiss.

Pursuing our circuit round the island east of the Point of Bragaster, we find a sandstone, which is coloured by green-earth, occupying an interval between masses of claystone-porphyry. The direction of the strata is about N. 15° W., dipping to the west at angles of about 20°. Again, to the east, as we approach the Kirksands, an amygdaloidal rock first appears, having a basis, consisting for the most part of argillaceous matter combined with felspar, the cavities of which are filled with calcareous-spar, heavy-spar, fluor-spar, quartz crystals, chalcedony and green-earth. This rock is alternated with thin beds of an indurated sandstone, occasionally passing into jasper. Here there are imperfect marks of stratification. At the Kirksands we have a sandstone manifesting a direction and dip nearly similar to those of the last strata, of the same name, described. Again, to the east, appears a conglomerated sandstone, alternated with an amygdaloidal rock, like the last noticed, the strata of which are vertical. East of the amygdaloidal rock we again meet with claystone-porphyry; which mass is probably the continuation of a more northerly one, intercepting all the strata hitherto described.

Crossing the porphyritic mass, which is imperfectly stratified, the second interval, supplied by strata, extends from the south-coast in a northerly direction to Housea Voe; it is limited to the east and north by the several porphyritic masses of Northhouse and Ollas Voe. These strata are chiefly of sandstone, which, south of Housea Voe, becomes conglomerate, containing small angular and rounded portions of the same rock, varied by the presence of green-earth: their direction is from N. 45° to 60° E., dipping to the west at angles of about 20°. North of Housea Voe, and extending to the head of Ollas Voe, are strata of sandstone alternated with amygdaloid. The stratification, when distinct, is in a direction of about N. 20° W., whilst the dip is to the west at angles of about 17°.

Continuing our circuit round the island, in order to observe the relations of the porphyry, we find, to the north-east of Papa Stour, a conglomerate rock, variously consisting of portions of sandstone, claystone-porphyry, and green-earth. Strata of this rock are interposed in all positions from the vertical to the horizontal, between beds of claystone-porphyry. Here we may in some places disengage from the porphyry round, hollow concretions, the drusy cavities of which are lined with quartz-crystals. North-east of the bank of Ollas Voe, the claystone-porphyry is occasionally prone to the conglomerate structure, and we find it alternated with thin beds of sandstone.

West of Ollas Voe, the porphyry presents no remarkable appearance; but near the most northerly point of the headland between Ollas Voe and Culia Voe, conglomerate rocks rest on the porphyry. East of Culia Voe, whilst claystone-porphyry is the lowest rock, conglomerate strata, into which the porphyry passes, are the next in point of superimposition, and an amygdaloidal rock is the highest in the series. Here the porphyry is imperfectly stratified. West of Culia Voe, the claystone-porphyry is uncombined with any other rock.

North-west of the Island of Papa Stour, near the entrance into Culia Voe, conglomerate strata rest, in nearly a horizontal position, on claystone-porphyry. But a little to the westward, we find the porphyry in a reversed relation, appearing to rest upon a conglomerated sandstone, and, to the south-west, upon a rock consisting of alternations of conglomerate and amygdaloidal strata. Here it is very probable, that the apparent superimposition of the porphyry merely involves the contact of one portion only of its bounding surface, which is *impendent;* for, as we pursue our course to the south-west, we find that a sandstone, which is connected with all the strata apparently subjacent, now comes in contact with another portion of the bounding surface of the porphyritic mass, which is *inclined.* Consequently, the same strata which in one place appear to be subjacent to the porphyry, are now the superimposed masses. From all these anomalous circumstances, it seems very evident, that the terms Superimposition and Subjacency, may lead to very erroneous notions in regard to the attachments of strata; since they involve contradictory appearances, which can only be reconciled, on a supposition that the edges of strata may be variously opposed to two different kinds of surfaces, described as *impendent* or *inclined*, and that these, at every step we take, may diversify the form of the individual rock affording attachment to strata.

Quitting these conglomerate and amygdaloidal strata of the north-west of Papa Stour, our examination of the island concludes with the uninterrupted continuation of the claystone-porphyry to the west and south-west of the island, until we reach the Point of Bragaster, from whence our circuit first commenced.

Before quitting the discussion of these rocks, a few words remain to be said with regard to the general relations of sandstone or granular quartz. I have hitherto considered this rock as possessing the character of a nucleus, since we have exhibited its apparent influence in determining the course and direction of other strata connected with it. But when sandstone or granular quartz assumes a conglomerated structure, its character appears to undergo some change. This change consists in the course and extent of its strata being determined by the presence of other rocks, such, as in the instance now given, by the claystone-porphyry of Papa Stour *.

THE GRANITIC DISTRICT OF SHETLAND.

The granite of this district is first traced from the north of the Isle of Vementry; it occupies the greatest portion of the Island of Meikle Rheu, and is inferred to be continuous through the channel between Meikle Rheu and Northmavine, from the circumstance of forming the insulated rocks named the Drongs; and, lastly, it extends from the south coast of Northmavine to the Island of Wya, situated to the north of the parish. The whole extent of the granite, supposing it to be continuous from Meikle Rheu, is 24 miles in length, and from 1½ to 5½ miles in breadth; it rises to a height of 1470 feet, forming Ronas Hill.

To the east of the granite, in junction with it, is a mass of sienitic greenstone, which may be traced from the Island of Meikle Rheu to the south of Ronas Voe. It is 12 miles in length, and about 3 in breadth.

These two masses of granite and sienitic greenstone, mutually penetrate each other by extensive processes, one of which I traced a distance of five miles; at the same time, insulated masses of granite occur in the sienitic greenstone, and *vice versa*.

Strata and Rocks connected with the Granite and Sienitic Greenstone of Northmavine.

The line of junction between the granite and sienitic greenstone is not, however, complete. A space, in one instance, is evident where a partial separation has occurred. This space is occupied by strata, and is bounded on the N. and W. by the granite, and on the south the presence of the granite is indicated by the insulated rock of the Drongs: it is bounded on the east by the sienitic greenstone. Thus, certain strata, forming an area of a mile and a half in length, and three quarters of a mile in breadth, appear to be inclosed on all sides by two unstratified rocks. These strata, constituting Hillswick Ness, exhibit a variety of directions, the most prevalent being nearly from west by south to east by north. The dip and angle are too confused to be stated with any degree of accuracy. This curious assemblage of rocks, in crossing them from north to south, are found to be arranged in the following order, viz. quartz, hornblendic gneiss, mica-slate, chlorite, and hornblendic gneiss. They are, at the same time, traversed by veins of felspar-porphyry and by greenstone. Here also is found steatite, talc, chlorite containing magnetic ironstone, cyanite, and actynolite.

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* For several interesting details on the rocks of Papa Stour, see Dr Fleming's Account in the first volume of the Wernerian Transactions.

Two series of strata are arranged to the east of the sienitic greenstone. To determine the situation and circumstances of the first series, it is necessary to refer to a space in the annexed geological map, bounded on the east by a mass of sienite, to be traced from Hagrasetter Voe to Glus Island, and on the west by the sienitic greenstone, the limits of which have been stated. This is occupied by strata running in a direction of N. by W. from one mass of sienite to the other, and meeting each by their lateral edges at various angles, with an inclination to the east. These rocks, which are much concealed by the covered state of the ground, appear to consist of hornblendic gneiss and chlorite, with an enclosed mass of limestone.

More northerly, a 2d series, continuous with the first, takes a course of N. 20° E. These strata form the Falling Hill and Ollaberry Hill; and as we cross them from west to east, appear to consist of hornblendic gneiss, with an intersecting mass of serpentine, mica-slate, chlorite, and quartz. Of these rocks, the more westerly, consisting of hornblendic gneiss with the serpentine, of quartz and mica-slate, are intercepted by the granite which occurs to the north of Colafirth Voe. The rest of the strata are continued northerly, the quartz being finally lost by the inroads of the sea at Calsta Ness; whilst the chlorite-slate may be traced as far north as North Rheu and North and South Holm, where it is associated with small masses of limestone. New strata, however, arise to the west of the chlorite-slate, consisting of mica-slate and gneiss, the southerly lateral edges of which meet the northerly bounding line of the granite at various angles. The strata of mica-slate are intercepted on the north by a mass of diallage-rock, occurring in the peninsula of Fethaland.

To the north of Fethaland, in the insulated rocks named Grunie and the Ramnay Stacks, is found a conglomerate rock, consisting of granite, felspar and quartz, the relations of which are not evident.

To the south-west of the granite is a considerable mass of claystone-porphyry, with a conglomerate and amygdaloidal rock of the same nature. The cavities of the latter are filled with carbonate of lime, quartz-crystals and calcedony. This mass occupies a district, bounded on the south by a line drawn from Braewick to Eshaness; on the west, from Eshaness to the entrance into Ronas Voe; and on the east, by the large mass of granite already described.

THE SERPENTINE DISTRICT OF SHETLAND.

The Gneiss of the Islands of Yell Sound, the large Island of Yell, West of Unst, &c.

Returning to the sienite of Yell Sound, we trace these strata from their junction with it, by their lateral edges, at the several islands of Yell Sound, named Brother Island, Little Rhooe and Samphray. Near the junction of the gneiss with the sienite, the strata are much traversed by veins of hornblende. The whole of the Island of Yell is composed of gneiss, as well as the islands to the west. The strata are everywhere intersected by small veins of granite, which, to the north-west of Yell, are almost as abundant as the strata which they traverse. The direction of the strata, disturbed much by these veins, may be stated at about N. 12° E. The dip is to the west, at angles of about 45°.

The northerly connexions of the strata are, for the most part, cut off by the sea. Some strata, however, may be identified in those of Hascosea, the small island of Linga, and in those of the west of Unst, where they are intercepted by a mass of serpentine, remaining to be described.

The Serpentine and Diallage of Fetlar, and the strata connected with them.

In the Island of Fetlar is a central mass of serpentine, which forms the Vord Hill. It is characterised by the quantity of chromate of iron which is disseminated throughout, in grains not larger than those of gunpowder, by the ferruginous appearance which it exhibits on decomposition, and by its noxious effect on vegetation. This mass presents two outlines, diverging from a point in a northerly direction, but inclining a little to the north-west; it is six miles long, and from one to two broad.

To the east of the serpentine, in Grutings Voe, are strata of mica-slate, clay-slate and chlorite-slate, associated with several small insulated masses of serpentine. These strata, in their junction with the large mass of serpentine, are opposed to it at various angles. To the east of these, along the whole of the east coast of Fetlar, are rocks of conglomerated mica-slate and chlorite-slate, containing portions of quartz, occasionally angular, but for the most part exhibiting an abraded appearance; whilst, at the same time, they are often observed to imperceptibly pass into the substance of the containing mass *.

To the west of the central mass of serpentine in Fetlar, are numerous insulated masses of serpentine and diallage alternated with chlorite-slate, glossy alum-slate, and mica-slate. Still more westerly is a cuneiform mass of diallage, and a similarly formed, though thinner, mass of serpentine. The serpentine at Odsta considerably disturbs the compass. Strata of gneiss, intersected by small veins of granite, complete the structure of the Island of Fetlar; these bound the western coast, and, in a direction of N. by E. and an inclination to the west, meet the serpentine at various and considerable angles.

At Lamhoga in Fetlar, in consequence of the decomposition of a peculiar white bed of gneiss, containing much felspar, a bed of porcelain earth is produced. This occurs on the estate of Arthur Nicholson, Esq. and may probably be an object of commercial notice.

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* These strata, which several years ago excited the attention of Professor Jameson, appear to have materially assisted his views of the nature of conglomerate rocks in general.

Distribution of the Serpentine, Diallage and Strata of Unst.

In the adjoining island of Unst, to the north of Fetlar, is another central mass of serpentine, in almost every respect like that of the central mass of Fetlar. This rock may be traced from the west of Gallowhill, near Belmont, bending in a north-easterly direction to the line of coast between Norwick Bay and the north of Balta Island. It is about ten miles in length, while its breadth gradually increases from one to three miles.

This mass of serpentine is particularly distinguished by the very abundant occurrence in it of the chromate of iron, chiefly observable in the neighbourhood of Balta Sound. I was first led to a search after this ore, by observing innumerable fragments of it strewed about the hill, and even employed for the purpose of fortifying the fences of the country. It is observed, first, in the form of imbedded masses, as at Buness, close to the house of the proprietor, Thomas Edmonstone, Esq. The extent of the greatest mass is not, however, apparent, as it is on one side concealed by the sea, and on the other by the deep soil of a meadow. It was traced 3 feet in breadth, and 15 feet in length. At Hagdale, near Haroldswick, the chromate of iron occurs in the form of numerous thin ramifying veins, 2 to 3 inches in breadth, but sometimes increasing to the breadth of 5 or 6 inches. Many masses are elsewhere observable, extending a few feet, and then losing themselves in a general dissemination throughout the whole mass. The chromate of iron is also in some hills diffused generally in granular particles, of the colour and size of gunpowder. Asbestus, amianthus and talc occur in many places, particularly at Swinaness, near Balta Island.

To the east of the central mass is the Diallage rock, of which the Vord Hill of Unst is formed, and which may be traced in a direction of N. E. by N. to Balta Island. It is seven miles in length, and two miles in breadth. In the diallage of Balta Island may be found beautiful specimens of asbestus. To the east of the diallage, from Wya Sound to Mouness, and in the Island of Wya, are strata of chlorite-slate associated with small insulated masses of diallage and serpentine; serpentine also occurs at the Island of Half Grunie off Mouness.

The rocks to the west and north of the central mass of serpentine have a very complicated distribution. A small mass of porphyritic gneiss (if it can be so called, for it shews very little of the stratified structure,) may be, in the first place, observed at Lambaness, and at the insulated rock named The Scaw. 2dly, May be remarked a cuneiform mass of quartz, containing some felspar, and occupying a site between Burravoe and the Loch of Cliff. 3dly, May be remarked a bed of limestone to the east of the Loch of Cliff.

Now, the space intermediate to the central mass of serpentine, the porphyritic gneiss, the limestone and the quartz, is occupied by the Hill of Saxivord, consisting of striated strata of mica-slate, which are connected with all the bounding rocks that I have mentioned, and which meet each of them at various angles.

With regard to the islands in the channel intermediate to the Islands of Unst and Fetlar, they consist of serpentine, diallage, and chlorite-slate, shewing that Unst and Fetlar may be considered as part of one formation.

I have at length concluded my account of the distribution of the rocks in Shetland, which, although a mere abstract, has extended itself to a length that I had not anticipated. In a country offering so many objects of notice to the geologist, I have, through the medium of this Journal, presented those phenomena only which might tend to throw some light on the nature of stratification; yet the form, distribution, and comparative heights of the hills, together with the changes which the rocks are in the process of undergoing from various existing causes, are distinct subjects of equal interest, to which I have not had space to advert.

The general conclusion from a disposition of rocks like that which I have described, is readily suggested. If the resemblance to nuclei which I have endeavoured to trace in the relations of certain mountain masses be admitted, then will the gradual manner in which the rocks at their junction pass into each other, assign to the whole of the hills of Shetland a cotemporaneous formation. But this opinion I offer with considerable diffidence, since the analogies upon which it is founded, do not by any means communicate to it the force of a complete induction. A number of facts are still required to decide questions that refer to the date of the formation of rocks; but these ought to be accumulated with an accuracy, that may seem unnecessary to the geologist, who fancies himself secure in the theory which he has built, and that this theory is as immoveable as the rocks to which it refers. In conducting, therefore, investigations necessary to give to geology the name of a science, the maxim of a philosopher of the last century, ought ever to form the leading principle: "Tum oportet incipere à simplicissimis, cognitu facillimis, atque certissimis; à quibus deinde pergendum ad ea semper, quæ proximo gradu harum conditionum prægressa attingunt, atque ita accuratè progrediendum, ad composita, obscurà, difficilia."

ART. V.—*Account of the Electrical Eels, and of the Method of catching them in South America by means of Wild Horses.* Abridged from HUMBOLDT's Personal Narrative.

REAL Gymnoti or Electrical Eels, inhabit the Rio Colorado, the Guarapiche, and several little streams, that cross the missions of the Chayma Indians. They abound also in the large rivers of America, the Oroonoko, the Amazon, and the Meta; but the strength of the current, and the depth of the water, prevent their being caught by the Indians. They see these fish less frequently than they feel electrical shocks from them when swimming or bathing in the river. In the *Llanos*, particularly in the environs of Calabozo, between the farms of Morichal, and the missions *de arriba* and *de abaxo*, the basins of stagnant water, and the confluents of the Oroonoko, (the Rio Guarico and the *Canos* of Rastro, Berito and Paloma), are filled with electrical eels. We at first wished to make our experiments in the house we inhabited at Calabozo; but the dread of the electrical shocks of the gymnoti is so exaggerated among the vulgar, that during three days we could not obtain one, though they are easily caught, and though we had promised the Indians two piastres for every strong and vigorous fish.

Impatient of waiting, and having obtained very uncertain results from an electrical eel that had been brought to us alive, but much enfeebled, we repaired to the Cano de Bera, to make our experiments in the open air, on the borders of the water itself. We set off on the 19th of March for the village ***Rastro de abaxo***; thence we were conducted to a stream, which, in the time of drought, forms a basin of muddy water, surrounded by fine trees. To catch the gymnoti with nets is very difficult, on account of the extreme agility of the fish, which bury themselves in the mud like serpents. We would not employ the *barbasco*, that is to say, the roots of the Piscidea erithryna and Jacquinia armillaris, which, when thrown into the pool, intoxicate or benumb these animals. These means would have enfeebled the gymnoti; the Indians therefore told us, that they would "fish with horses." We found it difficult to form an idea of this extraordinary manner of fishing; but we soon saw our guides return from the savannah, which they had been scouring for wild horses and mules. They brought about thirty with them, which they forced to enter the pool.

The extraordinary noise caused by the horses' hoofs makes the fish issue from the mud, and excites them to combat. These yellowish and livid eels, resembling large aquatic serpents, swim on the surface of the water, and crowd under the bellies of the horses and mules. A contest between animals of so different an organization furnishes a very striking spectacle. The Indians, provided with harpoons and long slender reeds, surround the pool closely; and some climb upon the trees, the branches of which extend horizontally over the surface of the water. By their wild cries, and the length of their reeds, they prevent the horses from running away, and reaching the bank of the pool. The eels, stunned by the noise, defend themselves by the repeated discharge of their electric batteries. During a long time they seem to prove victorious. Several horses sink beneath the violence of the invisible strokes, which they receive from all sides in organs the most essential to life; and stunned by the force and frequency of the shocks, disappear under the water. Others, panting, with mane erect, and haggard eyes, expressing anguish, raise themselves, and endeavour to flee from the storm by which they are overtaken. They are driven back by the Indians into the middle of the water; but a small number succeed in eluding the active vigilance of the fishermen. These regain the shore, stumbling at every step, and stretch themselves on the sand, exhausted with fatigue, and their limbs benumbed by the electric shocks of the gymnoti.

In less than five minutes two horses were drowned. The eel, being five feet long, and pressing itself against the belly of the horses, makes a discharge along the whole extent of its electric organ. It attacks at once the heart, the intestines, and the *plexus cœliacus* of the abdominal nerves. It is natural, that the effect felt by the horses should be more powerful than that produced upon man by the touch of the same fish at only one of his extremities. The horses are probably not killed, but only stunned. They are drowned from the impossibility of rising amid the prolonged struggle between the other horses and the eels.

We had little doubt, that the fishing would terminate by killing successively all the animals engaged; but by degrees the impetuosity of this unequal combat diminished, and the wearied gymnoti dispersed. They require a long rest *, and abundant nourishment, to repair what they have lost of galvanic force. The mules and horses appear less frightened; their manes are no longer bristled, and their eyes express less dread. The gymnoti approach timidly the edge of the marsh, where they are taken by means of small harpoons fastened to long cords. When the cords are very dry, the Indians feel no shock in raising the fish into the air. In a few minutes we obtained five large eels, the greater part of which were but slightly wounded. Some were taken by the same means toward the evening.

The temperature of the waters in which the gymnoti habitually live, is about 86° of Fahrenheit. Their electric force, it is said, diminishes in colder waters. The gymnotus is the largest of electrical fishes. I measured some that were from five feet to five feet three inches long; and the Indians assert, that they have seen them still longer. We found, that a fish of three feet ten inches long weighed twelve pounds. The transverse diameter of the body was three inches five lines. The gymnoti of *Cano de Bera* are of a fine olive-green colour. The under part of the head is yellow, mingled with red. Two rows of small yellow spots are placed symmetrically along the back, from the head to the end of the tail. Every spot contains an excretory aperture. In consequence, the skin of the animal is constantly covered with a mucous matter, which, as Volta has proved, conducts electricity twenty or thirty times better than pure water. It is in general somewhat remarkable, that no electrical fish, yet discovered * in the different parts of the world, is covered with scales.

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* The Indians assured us, that when the horses are made to run two days successively into the same pool, none are killed the second day.

It would be temerity to expose ourselves to the first shocks of a very large and strongly irritated gymnotus. If by chance you receive a stroke before the fish is wounded, or wearied by a long pursuit, the pain and numbness are so violent, that it is impossible to describe the nature of the feeling they excite. I do not remember having ever received from the discharge of a large Leyden jar, a more dreadful shock than that which I experienced by imprudently placing both my feet on a gymnotus just taken out of the water. I was affected the rest of the day with a violent pain in the knees, and in almost every joint. To be aware of the difference, which is sufficiently striking, that exists between the sensation produced by the pile of Volta and an electrical fish, the latter should be touched when they are in a state of extreme weakness. The gymnoti and the torpedoes then cause a twitching, which is propagated from the part that rests on the electric organs as far as the elbow. We seem to feel at every stroke an internal vibration, that lasts two or three seconds, and is followed by a painful numbness.

Gymnoti are neither charged conductors, nor batteries, nor electromotive apparatuses, the shock of which is received every time they are touched with one hand, or when both hands are applied to form a conducting circle between two heterogeneous poles. The electric action of the fish depends entirely on its will; whether because it does not keep its electric organs always charged, or by the secretion of some fluid, or by any other means alike mysterious to us, it be capable of directing the action of its organs to an external object. We often both tried, both insulated and uninsulated, to touch the fish, without feeling the least shock. When Mr Bonpland held it by the head, or by the middle of the body, while I held it by the tail, and, standing on the moist ground, did not take each other's hand,

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* We yet know with certainty only seven electrical fishes: Torpedo narke, Risso, t. unimaculata, t. marmorata, t. galvanii, Silurus electricus, Tetraödon electricus, Gymnotus electricus.

one of us received shocks, which the other did not feel. It depends upon the gymnotus to act toward the point where it finds itself the most strongly irritated. The discharge is then made at one point only, and not at the neighbouring points. If two persons touch the belly of the fish with their fingers, at an inch distance, and press it simultaneously, sometimes one, sometimes the other, will receive the shock. In the same manner, when one insulated person holds the tail, and another pinches the gills, or pectoral fin, it is often the first only by whom the shock is received. It did not appear to us, that these differences could be attributed to the dryness or dampness of our hands, or to their unequal conducting power. The gymnotus seemed to direct its strokes sometimes from the whole surface of its body, sometimes from one point only.

Nothing proves more strongly the faculty which the gymnotus possesses, of darting and directing its stroke according to its will, than the observations made at Philadelphia, and recently at Stockholm, on gymnoti rendered extremely tame. When they had been made to fast a long time, they killed from afar small fishes put into the tub. They acted at a distance; that is to say, their electrical stroke passed through a very thick stratum of water. We need not be surprised, that what was observed in Sweden, on a single gymnotus only, we could not see on a great number of individuals in their native country. The electric action of animals being *a vital action*, and subject to their will, it does not depend solely on their state of health and vigour. A gymnotus, that has made the voyage from Surinam to Philadelphia and Stockholm, accustoms itself to the imprisonment to which it is reduced; it resumes by degrees the same habits in the tub which it had in the rivers and pools. An electrical eel was brought to me at Calabozo, taken in a net, and consequently having no wound. It ate meat, and terribly frightened the little tortoises and frogs, which, not knowing the danger, placed themselves with confidence on its back. The frogs did not receive the stroke till the moment when they touched the body of the gymnotus. When they recovered, they leaped out of the tub; and when replaced near the fish, they were frightened at its sight only. We then observed nothing that indicated *an action at a distance;* but our gymnotus, recently taken, was not yet sufficiently tamed to attack and devour frogs. On approaching the finger, or metallic points, within the distance of half a line from the electric organs, no shock was felt. Perhaps the animal did not perceive the neighbourhood of this foreign body; or, if it did, we must suppose that the timidity it felt in the commencement of its captivity, prevented it from darting forth its energetic strokes, except when strongly irritated by an immediate contact. The gymnotus being immersed in water, I approached my hand, both armed and unarmed with a metal, within the distance of a few lines from the electric organs; yet the strata of water transmitted no shock, while Mr Bonpland irritated the animal strongly by an immediate contact, and received some very violent shocks. If I had plunged the most delicate electroscopes we know, prepared frogs, into contiguous strata of water, they would no doubt have felt contractions at the moment when the gymnotus seemed to direct its stroke elsewhere.

The electrical organ of the gymnoti acts only under the immediate influence of the brain and the heart. On cutting a very vigorous fish through the middle of the body, the fore part alone gave me shocks. The shocks are equally strong, in whatever part of the body the fish is touched; it is most disposed, however, to dart them forth when the pectoral fin, the electrical organ, the lips, the eyes, or the gills are pinched. Sometimes the animal struggles violently with a person holding it by the tail, without communicating the least shock. Nor did I feel any when I made a slight incision near the pectoral fin of the fish, and *galvanized* the wound by the simple contact of two pieces of zinc and silver. The gymnotus bent itself convulsively, and raised its head out of the water, as if terrified by a sensation altogether new; but I felt no vibration in the hands which held the two metals. The most violent muscular movements are not always accompanied by electric discharges.

The action of the fish on the organs of man is transmitted and intercepted by the same bodies that transmit and intercept the electrical current of a conductor charged by a Leyden vial, or Volta's pile.

In wounded gymnoti, which give feeble but very equal shocks, these shocks appeared to us constantly stronger on touching the body of the fish with a hand armed with metal, than with the naked hand. They are stronger also, when, instead of touching the fish with one hand, naked, or armed with metal, we press it at once with both hands, either naked or armed. These differences, I repeat, become sensible only when you have gymnoti enough at your disposal, to be able to choose the weakest; and the extreme equality of the electric discharges admits of distinguishing between the sensations felt alternately by the hand naked or armed with a metal, by one or both hands naked, and by one or both hands armed with metal. It is also in the case only of small shocks, weak and uniform, that the shocks are more sensible on touching the gymnotus with one hand (without forming a chain) with zinc, than with copper or iron.

Resinous substances, glass, very dry wood, horn, and even bones, which are generally believed to be good conductors, prevent the action of the gymnoti from being transmitted to man. I was surprised at not feeling the least shock on pressing wet sticks of sealing-wax against the organs of the fish; while the same animal gave me the most violent strokes, when excited by means of a metallic rod. Mr Bonpland received shocks when carrying a gymnotus on two cords of the fibres of the palm-tree, which appeared to us extremely dry. A strong discharge makes its way through very imperfect conductors. Perhaps also the obstacle which the conducting arc presents, renders the discharge more painful. I touched the gymnotus with a wet pot of brown clay without effect; yet I received violent shocks when I carried the gymnotus in the same pot, because the contact was greater.

When two persons, insulated or not insulated, hold each other's hands, and one of these persons only touches the fish with the hand, either naked or armed with metal, the shock is most commonly felt by both at once. It happens, however, also, that, in the most painful shocks, the person who comes into immediate contact with the fish alone feels the shock. When the gymnotus is exhausted, or in a very weak state of excitability, and will no longer emit strokes on being irritated with one hand; the shocks are felt, in a very vivid manner, on forming the chain, and employing both hands. Even then, however, the electric shock takes place only at the will of the animal. Two persons, one of whom holds the tail, and the other the head, cannot, by joining hands and forming a chain, force the gymnotus to dart his stroke.

In employing very delicate electrometers in a thousand ways, insulating them on a plate of glass, and receiving very strong shocks, which passed through the electrometer, I could never discover any phenomenon of attraction or repulsion. The same observation was made by Mr Fahlberg at Stockholm. This philosopher, however, has seen an electric spark, as Walsh and Ingenhousz had done before him at London, by placing the gymnotus in the air, and interrupting the conducting chain by two gold leaves pasted upon glass, and a line distant from each other. No person, on the contrary, has ever perceived a spark issue from the body of the fish itself. We have irritated it for a long time during the night, at Calabozo, in perfect darkness, without observing any luminous appearance.

ART. VI.—*Observations on Mr Menge's Account of his Mineralogical Journey in Iceland.* In a Letter from Sir G. S. MACKENZIE, Bart. F. R. S. L. and President of the Physical Class of the Royal Society of Edinburgh, &c. to Professor JAMESON.

DEAR SIR,

NOTWITHSTANDING the numerous investigations that have been carried on in volcanic districts by eminent observers, I am disposed to think, that many distinctions are yet to be made among volcanic productions, and in the manner of their formation, before we arrive at a clear developement of volcanic agency. We must understand perfectly what is meant by the word *lava*, the too profuse employment of which has unquestionably left us much in the dark. Mr Menge mentions in his letter to you, that in one of the Westmanna Islands and Eÿafialla-Jokull (neither of which I visited), he observed three different streams of lava, separated from each other by layers of trass. Now, it is well known, that every stream of lava that *flows* in the open air, assumes an appearance so rugged, that nothing is seen at all resembling what we commonly understand by a *bed*, which is a mass bounded by planes that are parallel, or very nearly so. Hence, I believe, that all those streams of lava, as they have been called, which appear in the form of beds, must have been formed under peculiar circumstances, which were calculated to prevent the rugged appearance which the surface lava commonly assumes, and to induce that of regular beds. It might be supposed, that the rugged surface of lava has been caused by its descending along an inclined plane. But much of that which Menge says he could not behold without horror, has proceeded over a level country; and I saw many other lavas of the same aspect, in similar circumstances. To explain the different appearances, I suggested the idea of submarine lavas; and I am still inclined to adhere to it, and to that of subterraneous lavas also, as best calculated to explain the various appearances of trap-rocks, and their relation to lava.

I still doubt, that any lava that has flowed in the open air, has assumed the columnar form. All that I saw tending to that form, in the Guldbringe Syssel, certainly had not flowed on the surface in the open air. I have, indeed, seen partial, but feeble, tendencies in detached masses to this form, but nothing at all resembling the regular appearance of columnar beds, such as are to be seen at Stappen, and in other parts of the Snæfell Syssel, as well as in other parts of Iceland.

It is highly satisfactory to me to have heard Menge give the same opinion that I had formed, with respect to certain rocks appearing to have been melted *in situ*, and this without his having seen my Observations on the Mineralogy of Iceland. What he calls a Felspar-lava, is not Greenstone, as you suppose, by placing that name in a parenthesis. It might, however, have been a greenstone previously to the action of heat upon it.

I confess that I am not able fully to comprehend what Menge intended to convey by *aqueous volcanoes*; and connecting, as he does in his letter to you, pseudo-volcanic rocks with water, is contrary to the idea we have of pseudo-volcanoes. I suspect that when he speaks of having found in his journey northward, a perpetual *alternation* of true volcanic and pseudo-volcanic rocks, he means a *succession* as he advanced, not that the one was superimposed on the other. When I first saw the ironshot trap-tuff, I also took it for sandstone, as many others have on looking at the specimens I brought to this country from Iceland and Faroe. I suppose you do not consider the application of the word *Neptunian*, proper in describing debris brought down by glaciers. *Neptunian*, I have always understood to be confined to formations from solution, in contradistinction to Plutonian. When Menge says, "All the members of the trap series are arranged (at Skagafiord) above each other in horizontal beds," and "some may be inclined to view these beds as streams of lava, formed at different periods;" he seems inclined to be of the opinion I have offered in my account of Iceland. He appears to consider only one mode of formation possible for lava, and not to take into account the effects of compression, or those of submarine or subterraneous flowing. In conversation Menge informed me, that he was perpetually puzzled what to think of Iceland; that he was one day tempted to consider the whole as of igneous formation, as I do; and on another, that it was partly of aqueous formation. He is to return to this singular country; and it is very probable that he will at last determine, that it will be better to ascribe the whole formation to one cause, Heat, acting under a variety of circumstances, and occasionally combined with water, than to insist on the exclusive operation of water in one spot, and of heat in another, thus rendering Iceland a vast collection of anomalies in geology. I will never cease pressing you to visit Iceland, because I am convinced that no geologist can form adequate conceptions of the agency of heat, without having seen this, or some country similar to it.

There is no doubt whatever, that some of the products of the hot-springs are in appearance glassy; and I should not wonder if Obsidian, properly so called *, were proved to have had its origin in water extremely hot.

I do not know what is meant by *volcanic water*. There is a spot in the Guldbringe Syssel, in the midst of what Menge aptly names the Congealed Pandemonium, where a great quantity of water rises, and forming a considerable stream, flows a mile or two, and is then lost among the lava, which he did not see. But whether this be what Menge calls volcanic water, I do not know; as it has no peculiar properties to distinguish it from the water of an ordinary river.

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* You are aware, that I pointed out a marked distinction between two substances hitherto indiscriminately called Obsidian, and one of which I propose to name Pumice-glass, from pumice being formed by melting it, and that substance being always found connected with it. They are easily distinguished by the eye.

I am totally at a loss with respect to his notion of the hot-springs producing lava, basalt, and trap-porphyry. Is it possible that masses of these, in a state of decomposition, could be mistaken for the act of their formation? Be this as it may, I have always been an advocate for the agency of water strongly heated; and I believe I am the only Huttonian who has ever pretended, that the fundamental principle of our theory, Heat acting under compression, rendered water a most powerful chemical agent. Most of the operations ascribed to your cold Neptunian element, I must always consider as imaginary; but those of Plutonic water may have done much, and will yet do more,—as the two elements combined may probably relieve us of much disputation, and at length unite two theories, which are clearly both right and both wrong, since the one sometimes explains what the other does not. "In Iceland," says Menge, "we find Volcanic and Neptunian formations conjoined; the connecting link between the two (transition?) being the Volcanic-Neptunian formation, which appears to be produced by hot-springs." I feel somewhat affronted that old Pluto has not been invited to join the party;—you will find him below, you may depend upon it. I really did not expect to be believed in the account I gave of the rocks of Iceland, at the time I published it, and I have waited impatiently for the result of a visit by a Wernerian. I could not desire more than what Menge has said of the tract I examined, that, with little exception, there is no true Neptunian trap in it. My views will not now be considered as having been taken with a prejudiced eye.

I think that Menge has attributed more than enough to the hot-springs, because I consider, that their external deposites are probably as different from the results which occur below ground, as stream-lava is from what it would have been had it cooled under a powerful compressing force. It is probable, that after he has seen the west of Iceland, including Snæfell Syssel, he will form a different opinion of the relative positions of the trap and volcanic districts. His Volcanic-Neptunian rocks, are my Submarine Lavas; and his ideas of the veins are somewhat Huttonian. I suspect that when Menge sees the hot-springs at Reikholt, he will find that they issue from rocks that are not truly volcanic. Yours sincerely,

Edinburgh, *Jan.* 1820. G. S. Mackenzie.

Art. VII.—*Account of the Trap and Clay-slate Formation extending from Llandegly to Builth in Brecknockshire.* In a Letter from Dr Gilby jun. of Bristol, to Professor Jameson.

Happening to pass through Builth three years ago, I was much surprised to find that the hills in front of the town are composed of trap-rocks. Incessant rain at that time prevented me from making any particular examination of the country; but in the summer of last year, I had another opportunity of exploring it in company with a friend, to whose activity and acute observations I am much indebted; and we soon found, that these trap-hills form part of a long range, running north-east and south-west, through an extent of eight or nine miles. The form of this chain is irregular, and it is difficult to describe it so as to give an adequate idea of its shape. The northern extremity is at Llandegly, where it is seen at what are called Llandegly Rocks. The appearance of the trap here, and in every other part of its course, is extremely characteristic. The hills which it forms are frequently of considerable height; and every where presenting an uniform roundness of contour, their outline is generally heavy and ungraceful. Upon ascending the highest part of Llandegly Rocks, the trap may be followed for a mile or more, forming a high crest or ridge; after which, it seems to spread itself into several parallel ridges, separated from each other by very distinct valleys, and finally terminates in a hill of considerable extent, called Carnethy, which comes down to Llanelwyth, and upon part of which Mr Thomas's house of Llanelwyth is built. The trap, as far as this part of its course, preserves pretty nearly the direction of north-east and south-west; but from this spot it seems to run out more to the west, and, crossing the river about half a mile above the bridge at Builth, spends itself in the ground about Park Wells. I have thus described the range of the trap from north to south, which must certainly be a distance of eight or nine miles; and its breadth, where it is spread out into separate parallel ridges, reckoning from Llandrindod Wells its western, to Bettys its eastern flank, cannot be less than between four and five miles.

In general, it is considered interesting in the description of a formation, to mention the different varieties of rock of which it consists; but, in the present instance, a particular detail of this sort would be quite unnecessary. Whoever has seen much of trap-rocks must have observed, that, by continually passing into each other, they present the greatest possible diversity of structure. I never was more impressed with this fact, than in traversing the trap hills of this district. It was hardly possible to move twenty yards, without finding the rock exhibit quite a different character from that which I had just left. Any person will easily satisfy himself of this truth, by examining the hill near the village of Llanelwyth, where, from numberless projections, he will scarcely obtain two specimens resembling each other. In observing, therefore, the mineralogy of this formation, I have selected such specimens as were characteristic, or which presented any thing singular in their composition, and these I have transmitted as an accompaniment to the paper *. The rocks that I chiefly observed are, Greenstone of every variety, Felspar, Felspar passing into hornstone, Wacke, Porphyritic greenstone, and Clinkstone in a quarry near Llandrindod Wells.

The next point of interest regarding the geology of this district, is the relation which the trap bears to the clay-slate formation; for the whole of the country, comprehending a very extensive circuit, is composed of these two rocks.

In ascending any part of the trap range, we at once perceive that it is quite shut in by a complete circuit of hills, so that the line of the trap formation appears like the diameter of a circle. These hills, as we fully ascertained, are composed entirely of clay-slate, with the exception of subordinate beds of sandstone, limestone, and grey-wacke. At the two extremities of the trap, viz. at Llandegly, and at the end of the range near Builth, the distance between the trap and the clay-slate is not very great, but on the sides of the range there is a considerable space of level country between them.

In describing the course of the clay-slate hills, we may commence the line from the hills immediately behind Builth, and proceed with it onwards to the long continuous ridge running south of, and parallel with the road to Radnor, and which is known, I believe, by the name of the Aberedway Range. From Llanvihangel Nart Melan, the range is continued north-

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* These have not been received.—Ed.

wards in a line north of the village of Llandegly to Penny Bont. On the west, the circuit is completed by the range running through Unnear, New Bridge, Llanavon Vach to Builth. Not only is the trap deposit inclosed by this circular range of clay-slate, but the clay-slate stratification occupies the whole of the low ground between the hills of the two formations. In skirting round the trap, and in examining the quarries and sections at the base of the formation, we every where found it in junction with the clay-slate. In attaining the Llandegly rocks from the road, the schist appears at the foot of the hill lying on the trap, but is soon lost in ascending the hill. The same is the case at the outskirts of the trap at Bettys, and, in the road to Builth, the clay-slate has in many places been cut through, while immediately to the right is part of the trap range. Near Builth, the Wye winds round the trap, while the bed of the river is formed of clay-slate. On the road to Llandrindod, there are numerous displays of clay-slate, but by deviating a little to the right of the road, the line of the trap is soon reached, and at Llandrindod, the high ground above the Wells belongs to the trap, and the plain below is composed of clay-slate, as may be seen at the small stream near the Rock-house.

Having thus described the range of the trap, and the mode of its association with the clay-slate formation, I shall now speak of the appearances which present themselves at the junction of the trap with the clay-slate.

So much having been said with regard to the derangement of position and alteration of structure produced by trap upon the rocks, it was of course an object of primary interest, in so extensive a formation as the present, to see as much as possible of the contact of the two formations: but in two places only did I meet with any exhibition of the actual junction of the clay-slate with the trap. As far as I can understand, the schist, in its proximity to the trap, is either hardened into a complete flinty-slate, or else into a soft bituminous rock, a variety indeed of the black drawing-chalk. This soft bituminous slate we frequently found in our walks round the trap, but I never found it but once in actual junction with the trap. In gaining Llandegly rocks from the road, we arrive at an opening near a tavern-house at the beginning of the ascent. This opening is in the black shale, and it must then lie nearly contiguous to the trap, as the ascent of a few feet brings us directly upon a sort of hardened wacke. In walking from Llandegly rocks to Bettys, I found in one or two places the black shale at the foot of the range, and at Bettys, near a mill, there is a considerable quantity of it. The edges above Llandrindod Wells, is composed of greenstone and clinkstone, but about half a mile from the Wells near the Rock-house, the black shale (if I remember right) is seen very extensively. I have found it in many other places, which it would be needless to mention, and which, in fact, it would be difficult to describe, from the want of names to fix their locality. I shall mention two other instances, in speaking of the junction of the trap with the clay-slate. This occurrence, as I have before said, I only remarked in two places, one of which is in a quarry near Mr Thomas's house of *Pen Carig ;* the other I observed in the bed of the river. In this quarry a great mass of greenstone is exposed, and on one side the clay-slate is seen resting on it, converted into a highly indurated rock. The exact relation which the trap maintains with the greenstone is not very evident, as the whole has a very confused appearance. Opposite to this quarry there is a gate, and after passing a little way through it, we come to a spot where an opening has been made in the rock, which is then the black schist described above; and here, again, it is evident, that it must lie very near to the trap.

The second instance where I met with the hardened clay-slate in contact with the greenstone, is in the bed of the river near Builth, about a mile up the river towards Rhyador. The spot cannot be missed, as the appearances which present themselves are too interesting and extraordinary to be mistaken. We here see the river broken by projecting mounds of rock, which proceed from both sides of the river, sometimes opposed to each other, sometimes jutting out alternately. These ledges are for the most part trap, and every where traverse the slate, so that the intervals between them are filled up by the schist. This in fact is the precise point of the trap range above alluded to, where, having altered its direction to the west, it crosses the river before spending itself in the ground about Park Wells. I regret exceedingly that my incapacity for drawing should not have enabled me to give a representation of the scene which here presents itself, as it is almost impossible to write a faithful description of it.

It would be tedious and useless to enter into a particular account of the number and composition of the different ledges of rock, and of the various appearances observable at each. I shall therefore content myself with giving the following remarks.

The first thing which strikes the attention, is the hardening of the clay-slate almost every where, at its union with the greenstone; I say almost every where, for at one spot (I think the fourth ledge) the soft bituminous slate lies immediately upon the greenstone. The induration of the clay-slate is seen very beautifully at the first of these projecting ledges* of rock, where the greenstone is flanked on both sides by a complete flinty slate, so that the slate lies over the trap like the roof of a house. It is worthy of remark, however, that there is no distinct line of separation between the schist and the trap; on the contrary, there is a gradual passing of the greenstone into the hardened slate, and it is also curious that the slate, or rather the flinty rock, at its actual union with the trap, is not stratified, the stratification being manifest only when a little removed from the greenstone. The dip of the slate is every thing that is perplexing; sometimes it lies in a conformable manner upon the trap, sometimes it appears to dip under the ledge, as is the case at a tongue of rock, (a little above the island in the middle of the stream,) where the slate on one side is dipping under, and on the other side stands quite perpendicular. In other places, the slate seems shattered and turned about in every direction, and several times I observed large patches of the indurated schist completely contained in the greenstone. At the first tongue of rock there is an example of this sort, and also opposite the island on the Parkwell side of the river. In several places we observe the clay-slate, as it were, squeezed into the trap, and *vice versa.*

The effect produced by the greenstone in indurating the clay-slate, does not extend very far, as it is evident that the space between the ledges into which the water flows, has been originally occupied by the soft slate, which has been subsequently washed away by the flowing of the stream.

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* These, and the following remarks, refer chiefly to that side of the river adjoining the Rhyador road; and by the first ledge, I of course mean the nearest to Builth.

I have said that most of the ridges projecting into the bed of the current, are composed of trap. This, however, is not always the case, for there are several composed of an exceedingly hard stratified limestone, occurring in beds in the clay-slate, and which is frequently so hard as not to yield to the knife. Two of these limestone ridges are seen between the first and second great ledge of trap. The limestone is also sometimes mixed with the trap, as is the case at the third great ledge, where the stream runs in a narrow chasm in the trap, near an oak which stands in the middle of the stream. On the north side of this tongue of rock, the slate is mixed with the limestone in a very curious way, the limestone having apparently been disrupted from a regular bed, and appearing in detached lumps in the slate. Higher up, the small island above alluded to, is composed of trap mixed with limestone, sometimes affording specimens somewhat resembling Verde Antique.

I have now a few words to say upon the subject of organic remains. The trap is, as usual, entirely destitute of them. In no instance did I observe any thing like a fossil remain in the trap. In different situations we found the clay-slate containing orthoceratites, trilobites, and curious impressions of a small shell like a limpet. I have a very fine orthoceratite which I obtained from the clay-slate between The Three Cocks and Builth. In the quarry in Mr Thomas's grounds, we found the hardened slate full of trilobite impressions, which are sometimes very delicate and beautiful. The fossil is quite different from the Dudley one, and precisely the same as that which I have seen from the clay-state in other parts of Wales. The limestone and sandstone which occur as beds in the slate, likewise contain organic remains. In the sandstone I have frequently seen nests of a peculiar kind of beaked anomia; and we generally found the limestone crowded with madrepores, tubipores, small branches of coral, and several kinds of shells, most of which might readily be identified with those found in the Dudley limestone. In fact, from the nature of the organic remains alone, it is impossible for a moment to hesitate in pronouncing the formations above described, as belonging to the Transition series.

In common routine, the sequel to the history of a trap formation, should be some attempt to reconcile the appearances I have described to one or other of the two prevailing theories; but as I have not the least interest in the inquiry, whether the earth was formed by fire or by water, I shall abstain from any discussion on the subject. I would merely wish to observe, that the hardening of the clay-slate in the neighbourhood of the trap, and the intermixture of the two formations, may be as well explained, from the way in which the consolidation took place, as upon the Huttonian notion of subsequent violence. I am aware, that the induration of the clay-slate, and the appearances of disruption in the adjacency of the trap, will be claimed by the Huttonians, as a fresh verification of their theory; but the impartial geologist will immediately reflect, that if the induration of the clay-slate had resulted from the agency of fire, the same effect ought always to have taken place; but I have alluded to one spot where the *soft clay-slate* lies in contact with the trap. In fact, from any thing I saw to the contrary, the opposite opinion may be maintained with equal probability,—that the trap is the more ancient formation,—that the clay-slate had been deposited around it,—and that the disturbance and eccentric appearances observable at the foot of the range, were the effects of a particular kind of attraction in the crystallizing mass naturally ensuing, where one formation ceased, and another began.

There is one fact which will hardly be looked for, according to either theory. In crossing over from Llandrindod to Bettys, I found an opening in the very midst of the trap deposit entirely of clay-slate.

Art. VIII.—*Description of a New Perspective Machine* *. By the late James Watt, Esq. LL. D. F. R. S. Lond. and Edin. Member of the National Institute of France, and of the Batavian Society of Rotterdam.

THE perspective machine was invented about 1765, in consequence of my friend Dr James Lind having brought from India a machine invented by an English gentleman there, I believe a *Mr Hurst.* It consisted of a board fixed on three legs perpendicularly, upon which, close to the bottom and near the ends, were placed two small friction wheels, upon which a horizontal ruler rested, and could be moved endwise horizontally. This ruler was about twice the length of the board. On the middle of this ruler was fixed perpendicularly another ruler, reaching a little above the upper edge of the board; and in this last ruler there was a groove, similar to that of the slip of a sliding rule, which was also, like that, furnished with a slider, made to move freely up and down in it; and the upper end being pointed, served for an index.

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* The Editor is in possession of one of these machines, presented to him by Mr Watt, and constructed by himself.

In the bottom of the groove in the perpendicular ruler, there was a slit cut quite through the ruler, nearly from one end to the other. In the lower end of the slider was fixed a pencil, the point of which reached quite through the ruler to the paper to be drawn upon, which was stretched upon the board. An arm projecting forwards was fixed to one of the upper corners of the board (I do not remember how), and upon its end nearest the draughtsman, it carried a sight or eye-piece, consisting of a small piece of metal with a hole in it; and this eye-piece was elevated about half the width of the board above its upper edge. The rulers, sliders, &c. were made of brass, and were consequently heavy, but they moved easily on the pullies or friction wheels.

In using the machine, the board being placed at right angles to a line supposed to be drawn from the middle of the object which was to be delineated, and the sight adjusted so as to give a proper scale, the socket of the pencil was taken in the hand, the eye applied to the sight, and the index or acute top of the slider was made to travel over the lines of the object to be delineated, which it was enabled to do by a composition of the horizontal motion of the lower ruler on the wheels, and the perpendicular motion of the slider on the upright ruler. The pencil then described the lines upon the paper.

This instrument very readily described perpendicular or horizontal lines, as these accorded best with its natural motions; but in diagonal or curved lines, it was difficult to make the index follow them exactly, and the whole motions were heavy and embarrassing to the hand, and the instrument itself also was heavy and too bulky.

I wished to make a machine more portable and easier in its use, and at the suggestion of my friend Mr John Robison, (afterwards Professor Robison), I turned my thoughts to the double-parallel ruler, an instrument then very little known, and, I believe, not at all used. After some reflection, I contrived the means of applying it to this purpose, and of making the machine extremely light and portable.

The machine consisted of a box, about an inch and a half deep on the outside, 13 inches long, and 5 inches wide, and hinged so, that when opened it formed a flat board, A, B, Plate VII. fig. 7. and 8., of 13 inches long and 10 inches wide, on which the paper was stretched. It was kept open by means of three legs, C, C, C, which were fastened to the back part of it, and served to support it at a proper height. From the right hand upper corner of this box or board, a jointed arm, D E, projected forward to carry the eye-piece or sight, F, which could, by means of the joints, be adjusted higher or lower, nearer to or farther from the board, as might be required. To the lower edge of the board were attached two thin slips of wood, G, G, 10 inches long and 10 inches apart, and to the lower ends of these slips was attached the lower side of a double parallel ruler, H, I, K, every member of which was 10 inches long between centres; so that when fully open, it formed two squares, joined by one side of each, and in other states formed lozenges, or rhombuses of different degrees of obliquity. This double parallelogram was formed partly of thin slips of wood, H, I, K, and partly of brass much hammer-hardened, and all very light.

To the middle, K, of the upper side of the higher parallelogram was fixed, at right angles upwards, another slip of wood, L, about 11 inches long, and ending in a brass point, which served for an index, which, by the construction, could be moved equally easily in every direction, and with very little friction, and at the same time all the positions of the rulers were always parallel to each other. A pencil, pressed upon by a spring, was fixed in the junction of the perpendicular slip or index at K.

A paper being stretched upon the board, and the sight being moved to a proper distance from the board, generally about

18 inches, the hand being applied to the pencil socket, (for the pencil was not pressed upon by the hand), the upper point of the index was led along the lines of the objects intended to be delineated; and when perpendicular lines occurred, the index pointing to the upper end of them, the finger of the left hand being applied to the board touching the perpendicular slip, and the pencil drawn downwards, the line would be straight, and in the same way the horizontal slip served as a guide for horizontal lines. All others were drawn by the eye guiding the index, and, if the paper was smooth, could be drawn very correctly.

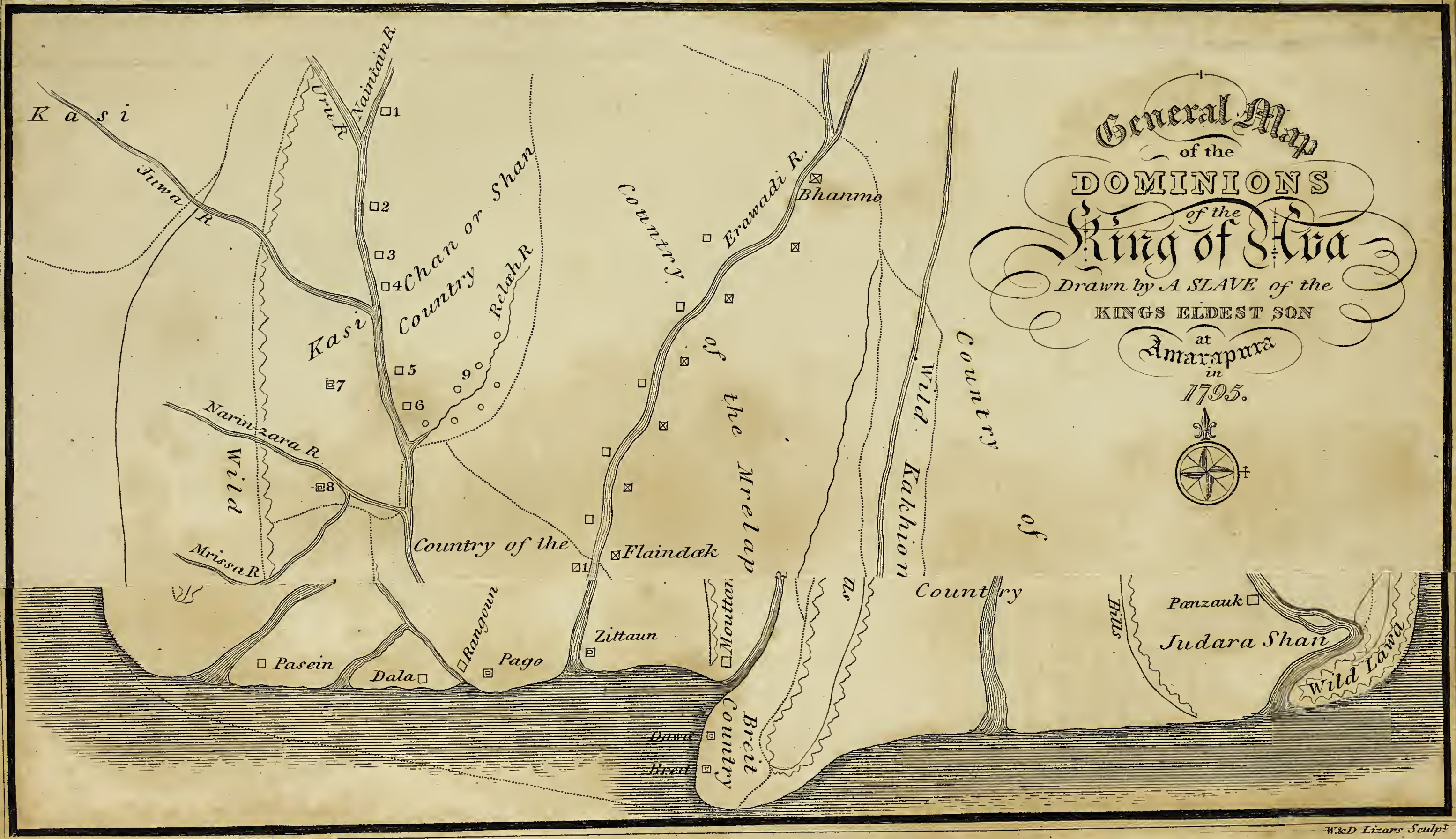
The whole of the double parallelogram and its attached slips, (which latter were contrived to be easily separated from the board), were made capable of being readily folded up, so as to occupy only a small space in the box, formed by the board when folded up. The sight-piece also folded up, and readily found its place in the box, which also contained screws for fixing on the legs of the instrument, and the box, when shut, could be put into a great-coat pocket. The three legs were made of tinned iron, tapering, and every one a little smaller than another, so that they went into one another, and formed a walking stick about 4½ feet long.

I made many of these instruments about the time mentioned, perhaps from fifty to eighty; they went to various parts of the world. Among other places several went to London, where George Adams *senior* copied and made them for sale.

Art. IX.—*An Account of a Map of the Countries subject to the King of Ava, drawn by a Slave of the King's Eldest Son.* By Francis Hamilton, M. D. & F. R. S. & F. A. S. Lond. & Edin. Communicated by the Author. (Concluded from p. 95.)

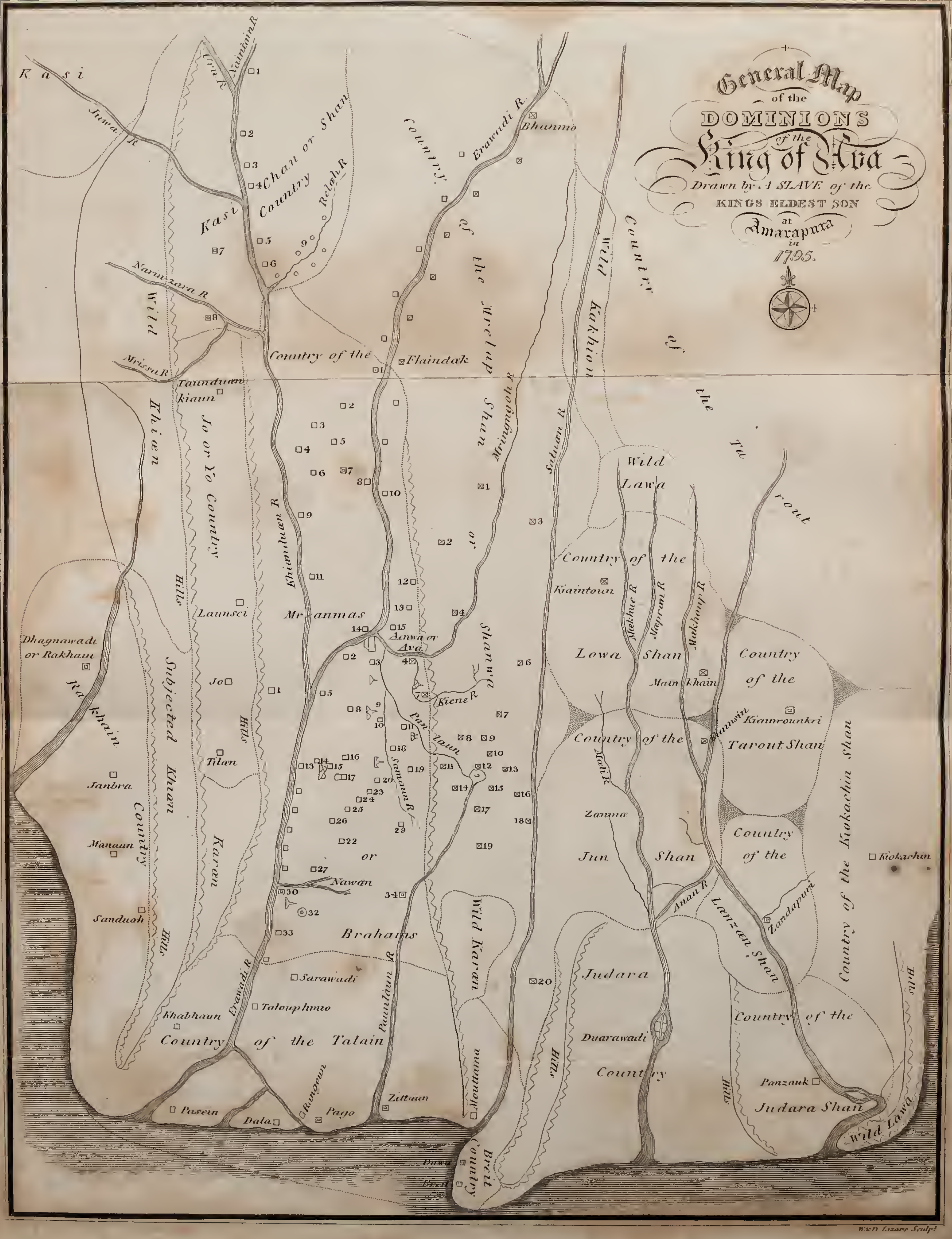
To explain the names in this Map, I may begin at the north and west with the Kasi country, which is that called Cussay by Mr Arrowsmith, and Meckley by Major Rennell, its capital being Manipur. None of these names, however, are used by the

PLATE X.



W.&D. Lizars Sculpt.

Edinburgh Published by A. Constable & Co 1820.



W. & D. Lizars Sculpt.

Edinburgh Published by A. Constable & Co 1820.

natives of the country, who call themselves Moitay. Although the princes of this country claim a descent from Babhrubahan, the son of Arjun, by Ulupi, daughter of the Devil, that is, of a woman who was not by birth a Hindoo; and although the claim to this most ancient descent is admitted as true by all Hindus, and mentioned in their records; and although the Moitay are worshippers of Vishnu, yet their language seems to me radically distinct from the Sangskrita, and their features entirely resemble those of the other inhabitants of the Farther Peninsula. Beyond Kasi, the Mranmas place to the west Akabat, which we call Kachar, and to the north Tæhka, which we call Asam; and these may be considered as clearly belonging to the peninsula, although not included in this map, and although the natives of both countries now use the dialect of Bengal.

The country of the Kasi Shan, on the upper part of the Khiænduæn river, is not mentioned by Major Rennell nor by Mr Arrowsmith, in his Map of Asia; but is slightly noticed by the latter, under the name of Nora, in the Map of Asam, published along with that of Hindustan, from materials which I furnished. Nora, or the country of the Kasi Shan, when I was at Ava, was tributary to the King of the Mranmas, but had princes of its own of the same family with the dynasty which then governed Asam. The natives speak a dialect very little different from that of Siam, and call themselves Tay Loun; for the race called Shan by the Mranmas call themselves Tay, and Loun is the specific term for this portion of that extended race. By their neighbours of Kasi or Moitay, this kingdom is called Bong.

South from the Kasi Shan is the country of the Io or Yo, a branch of the Mranma race, which occupies chiefly a territory on the banks of the Yowa, between two chains of hills, the mountains of the Khiæn on the west, and that called Dankhii on the east. The latter is of little elevation, and ends on the Erwadi, a little below Pugan. The streams from the west side of the Khiæn mountains run towards Arakan.

The mountains of the Khiæn, above mentioned, are said to be of great extent and considerable elevation, and are occupied chiefly by the tribe called Khiæn, from between the 12th and 13th degrees of north latitude, to between the 18th and 19th, that is, for about 400 miles; but the breadth occupied by this people is in a small proportion to the length. The Khiæn form one of the rude original tribes of the peninsula, and the greater part is entirely independent of any more cultivated race; but those who live towards the south are exposed to the inroads and commercial oppressions of the Mranmas, and submit to a limited obedience. Both sexes of this tribe are distinguished by having their faces, as well as their bodies, tatooed, to use a term of the South Sea islanders, now common in our language. The Khiæn have made more advances in manufacture than any other of the rude tribes of the Farther Peninsula, and weave silk cloths that are in high request at the court of Ava.

Farther west than the independent Khiæn, but not mentioned in this Map, a very large space is occupied by the most warlike and extended of these rude tribes, which is called Længæh by the Mranmas, a name changed by the Bengalese into Lingta; but among these Hindus, this rude tribe is more commonly called Kungky Kooky, or, as Sir William Jones wrote, Cuci. Most of this tribe, however, with whom I have conversed, called themselves Zou, and their territories extend close to Manipur and Kachar. Some of their chiefs seem to be possessed of a little power, and on predatory excursions can bring several thousand men to the field.

South from the Længæh or Cuci, and west from the Khiæn, that have become tributary to Ava, is the country called Rakhain, a name which has been corrupted by various people into Roang, Roshawn, Aracan, &c. This, however, is rather the vulgar name of the capital than of the people, who, by those of Ava, are called Great Mranmas, as being the original source of the whole race. The people of Rakhain, however, write their name Marama, making it consist of three syllables, while in the orthography of Ava it has only two, and the R in their pronunciation is changed into Y or J. From the name Maga, Mogo, Moghi or Mug, given by the Portuguese, and, perhaps, Low Bengalese, to the Rakhain, Dr Leyden imagined this to be the Magadha of the Hindu writers, as if the principal kingdom in India or Bharatkanda had been situated in an obscure corner of the Farther Peninsula, and not on the banks of the Ganges. This part of the Map is very defective, the towns called Janbra and Manaun being on two islands, and not on the Continent. The kingdom of Rakhain, now subject to Ava, has at times been very powerful, and has extended all over the western portion of the peninsula; for besides numerous rude tribes, and several petty chiefs of Hindu origin, it had subjected the Sakmas or original inhabitants of Chatigang, the Tripuras, who inhabited the eastern bank of the Brahmaputra in the lower part of its course, and the Asam, who held both sides of this great river higher up in its course.

East from the southern part of the Rakhain country, between it and the territory of Ava and Pago, we have a mountainous tract, occupied by a rude tribe called Karæn by the Mranmas, and probably the original inhabitants of all the country east from thence to the frontier of Siam. The woods every where on the hills between Prin and Taunu, and south from thence to the sea, are occupied by these simple people, who carry on most of the cultivation, and supply the wants of the Mranmas and other inhabitants of the towns: so that between Prin and Rangoun, I scarcely observed any cultivation, but what was the labour of the Karæn.

East from the southern part of the mountains occupied by the Khiæn and Karæn, is the country of the people by the Mranmas called Talain, and by themselves Mon. By Europeans this country is called Pegu, from its capital, the Pago of the Mranmas, several of whose monarchs have resided in this city, and the Mranmas now form a large proportion of the whole inhabitants of the country, many of the Talain or Mon having retired to the kingdom which we call Siam, where they are much encouraged, their men being eminent for acuteness of understanding, and their women for agreeable manners.

North from the country of the Talain, on both sides of the Erawadi and Khiænduæn, is the proper country of the Mranmas, who, for two centuries past, have in general been the most powerful nation in the peninsula; but acknowledge a descent from the Mranmas of Rakhain. Their country by Europeans is commonly called the Kingdom of Ava, from a corrupt pronunciation of Ænwa, the vulgar name for the capital; and the names Mranma, Burma, Birma and Brahma, often given to the nation, are all probably corruptions of Marama, used by the people of Rakhain, from whom, as I have said, those of Ava derive their origin. Brahma is the corruption of this name commonly used by the natives of Hindustan; and I suspect that Dr Leyden was totally misinformed, when he considered the Sangskrita word Varma as the name of this people. Several Hindu princes have used Varma as a title; but the most celebrated persons of this name were not a nation, but a dynasty, governing the impure tribe of Kirata or Kichak, and who long held Nepal, and conquered several countries in the north and east of Bengal. It is possible that some of these princes may have penetrated to Rakhain, and from thence to Ava; but, unless we knew Dr Leyden's authority, much reliance cannot be placed on his authority, as he evidently was but slightly informed on the subject, did not know the name by which the people of Ava call themselves, and gave them one, Varma, which no combination of their letters will express. The term Birman Empire, given to the kingdom of Ava by my late worthy friend Symes, is the Persian plural of Birma, one of the vulgar corruptions of Marama, he having corresponded with the government of Ava in the Persian language. The original inhabitants of the Mranma country, before the Chinese invasion, were probably Khiæn, as the Mranmas still retain the custom of tatooing on their legs, although they do not disfigure their faces with this attempt at ornament.

Every where on the north and east, the proper country of the Mranmas, is bounded by districts occupied by the people which they call Shan, but who call themselves Tay. From the Mranma word Shan, through the Portuguese orthography, is no doubt derived Siam, the name we give to the most distinguished nation of this race. I have already mentioned another nation of the same, the Tay Loun or Kasi Shan. East from this people, on both sides of the Erawadi, between the Mranmas and Chinese, and extending from thence far south between the Mranmas and the Saluen river, is a numerous people of the same race, governed by many hereditary chiefs called Zabuas, and tributary to Ava. By the Mranmas this branch is called Mrelap Shan or Shanwa, and the king of Ava, among his titles, usually assumes that of Sovereign of the nine provinces of Shan (Ko-shan-pri,) meaning the nine chief provinces of the Shanwa, that pay him tribute. There can be little doubt that this is the same country with that in the Universal History, p. 153. called Ko-sang-pyi, the R in Koshanpri being sounded exactly like Y. According to the Universal History, Kosangpyi lies west from the northern Laos, and has on its west again the great forest of Pahimapan, which is no doubt the mountainous ridge, that, rising on the banks of the Erawadi, half way between Ava and Bhanmo, on the frontier of China, runs south, a little inclining to east, until it approaches the sea at Moutama or Martaban, and separates the country of the Mranmas from that of the Shanwa. Where I saw this ridge, near Amarapura, it appears to be of a considerable height, probably 4000 or 5000 feet perpendicular; but several rivers pass through it, and there are many passages for troops, so that it does not seem to form a boundary of strength. In this country of Kosangpyi, the authors of the Universal History, p. 136. justly place the Tay-yay or Great Siammese of Loubere, and probably the Kalaminham of Mendez Pinto, who went to the court of its king in 1545, when the whole of the Shanwa cities were probably united under one native prince; but they have now been long subject to Ava, and governed by petty princes called Zabuas.

In the south-west corner of the territory occupied by the Shanwa, is a large hilly tract occupied by Karæn, who, in 1795, rejected the authority of the King of Ava, and bordered on the country of the Talain. These retain the primitive rudeness, and were more protected by the forests and fastnesses which they held, than by their skill or energy in the use of arms.

South from the east end of the Talain country, is that by the Mranmas named Breit or Byeit, which in the map occupies a small space, but in reality is of considerable dimensions, extending along the sea-coast from about the 10th to the 16th degree of north latitude. The Breit of the Mranmas, as appears from their language, are of the same race with these conquerors, but were long subject to Siam, although they now belong to Ava, and are separated from the kingdom of Siam by a considerable ridge of hills, which extend far to the north, interposed between the dominions of Ava and Siam, as these powers stood in the year 1795. Breit, the capital city of this territory, is the Mergui of Europeans.

Previous only a short time to my having been in Ava, Siam had been subject to the Mranmas; but after a bondage of some years, the Siammese had thrown off the yoke, and had entirely recovered their independence, although several states, formerly tributary to Duarawadi or Iudara, as its capital is called in the Pali and vulgar languages, still remained subject to Ava, or had at least refused obedience to the new dynasty. The Siammese call themselves Tay Noe or Little Tay; but by the Mranmas they are called merely Iudara or Iudaia, both pronounced Yudaya, after the vulgar name of the ancient capital. Although the Mranmas consider the Siammese as belonging to the Shan race, they do not call them Iudara Shan, because they have given that name to the people of what we call Cambodia. The inaccuracy of Loubere's map of this kingdom, did not escape the authors of the Universal History, (p. 195.) The map which I now publish, regarding Siam at least, is equally defective; for, although the author introduces two large countries between it and China, he places it nearly in the same latitude with the kingdom of Pegu, that is, his Talain country, and gives it a less extent, omitting altogether the Gulf of Siam, the coasts of which form the larger proportion of the kingdom.

On the north-west of Siam or Iudara, is a considerable extent of hills and forests occupied by the tribe called Lowa or Lawa, many of whom are also scattered among the forests of the countries occupied by the Shan or Tay nation, although it is only in a few places that they are noticed in a map on so small a scale. I imagine, that these Lowa or Lawa are the original inhabitants of these countries, and that, mixed with the kindred race of Chinese, and with certain colonists from Hither India, they form the Shan race.

North from these Lowas, who are partly tributary to Siam, and partly to Ava, the slave places the country of the Iun Shan, the capital of which is Zænmæ. There can be no doubt that this is the country which, in the Universal History (p. 135. 137.), is called Jangoma, and that the capital is the same with the Chiamay of Loubere.

North from the Iun Shan is the country of the Lowa Shan, who retain the name, which I consider as belonging to the rude tribe that, mixed with Chinese and Hindus, has given origin to the Shan race. This term Lowa or Lawa is no doubt the source of the names Lao, Lawho, Lau or Laho, applied by various authorities to the same people; and the Lowa Shan of the Mranmas is no doubt the same with the Northern Lao or Laho of the Universal History, the capital of which, about the middle of the 17th century, was called Leng, by the Chinese at least. But that city stood on the bank of the Menan Tay, a branch of the Menan Kong, or Mekong of the Chinese, which is the Mækhaun of the Mranmas. Menan Tay is therefore the Mækhoup of this map; while Kiaintoun, the present capital, is situated beyond the river of Siam.

North from the Lowa Shan, which Mr Dalrymple seems to have placed too far in that direction, is a mountainous space at the sources of the river of Siam, which is occupied by an independent and rude tribe of Lawa. To the north-west of this space in the slave's map, is placed a still more extensive tribe, called Kakhiæn, which occupies both banks of the Saluæn for some way after this river leaves China. As I shall have no farther opportunity of mentioning this people, I may here state that they differ both in manners and language from the Khiæn, and are readily distinguished by their tatooing only a small spot between the eyes. The Kakhiæn, who inhabit the banks of the Saluæn, are independent, and very troublesome to the merchants going to China, being of a more warlike disposition than most of the other rude tribes. A considerable number of the Kakhiæns has, however, been rendered tributary, and forms a large proportion of the inhabitants in the principality of Bhanmo, which occupies the space between the Erawadi and China.

East from the Lowa Shan, and from the great Mækhaun river, the map of the slave places a country which is called Tarout or Chinese Shan; for the Tarout of the Mranmas are the people we call Chinese. These Tarout Shan probably occupy the north-western part of Tonquin, as laid down by Mr Arrowsmith, but are probably one of the two small kingdoms to the west of Tonquin, mentioned in the Universal History (p. 452.) by the name of Law-chiva, which should evidently have been printed Law and Chiva; Law being the Lowa Shan of the Mranmas, and Chiva their Tarout or Chinese Shan, the capital of which is Kiainrounkri. When I was at Amarapura, this would appear to have been held as a principality tributary to Ava.

South from the Tarout Shan, on both sides of the Mækhaun river, is the country of the Lænzæn Shan, evidently the same with Lanjang, or Southern Laos of the Universal History (p. 146.), although the authors of this learned work were mistaken in supposing Lanjang to be the name of the capital, which is called Zandapuri.

It was stated at Ava in 1795, that these four principalities of Shan, namely, Yun, Lowa, Tarout, and Lænzæn, were governed by an equal number of hereditary chiefs, tributary to the king, and held in subjection by two great military officers, residing with strong garrisons at Kiainsin and Mainkhain, near the Mækhaun river. Since that time, there is reason to suppose that the King of Cochinchina has wrested from Ava, not only the two eastern principalities, but also these two strongholds, which seem to form the country that in the Universal History (p. 152.) is called the provinces of Kyanseng and Kemerat, in which case, the river called in that work Menantay, must be the Mækoup of the slave; and the territory belonging to these strongholds originally belonged to the Lowa Shan, who now occupy only the western portion of their territory.

South from the Lænzæn, the slave's map has, on both sides of the Mækhaun, the Iudara Shan, subject to the Iudara king, or Siam. This is the country called Kamboja in the Universal History, and Cambodia by Mr Arrowsmith. It has seldom been independent, but has generally been tributary to either Cochinchina or Siam. The latter was the case in 1795; but I believe the power of Cochinchina has since extended over this as well as over the other countries on the Mækhaun.

On the mountainous tract east from the lower part of the Mækhaun, in this map, very much reduced from its proportion of extent, the slave places Wild Lawa, evidently the same with the Loys of the Universal History (p. 425.), that is, the original inhabitants of Champa or Siampa, who have been long subject to the Cochinchinese.

North from these Lawa, along the sea-coast, the map places the Kiokachin Shan, which term here evidently includes both

Cochinchina and Tonquin. The Mranmas in general call the people of both these countries Kio; and in fact they form one nation, assuming to themselves Angnam as a common name, and speaking one language, called Anamitic, of which Alexander de Rodez has published a dictionary and grammar. Kio Kachin is, however, no doubt the source from which we derive the Cochin of China, to distinguish it from the Cochin of India; and this part of the Anamitic nation having for some time been by far the most powerful, the compiler of the map has satisfied himself by mentioning it alone. The more especially as, when it was compiled, a large proportion of Tonquin seems to have been subject to Ava, forming the principality of the Tarout Shan. The Mranmas, however, often distinguish the two divisions of the Kio, or Anamitic people, by calling the northern Kiobiain, and the southern Kiodain.

I have already mentioned, that China is by the Mranmas called the country of the Tarout, which accordingly occupies all the north-eastern part of the map.

ART. X.—*On the Changes of Colour in the Feathers of Birds, independent of Moulting.* In a Letter from the Rev. JOHN FLEMING, D.D. F.R.S.E. & M.W.S. to Professor JAMESON.

MY DEAR SIR,

LIVING at a distance from the seat of Science, it is only within these few days that I have had an opportunity of perusing the second part of the twelfth volume of the Transactions of the Linnean Society. The pleasure attending the examination of its contents was greatly heightened, when I perceived many illustrative examples of the truth of an opinion which I have entertained for many years, namely, "That the colours of the hair of quadrupeds, and the feathers of birds, change with the season, independent of the ordinary processes of *casting and moulting*." That this opinion has not been generally adopted, need not excite any surprise, when we consider that many zoologists regard the feathers as destitute of every kind of circulation, and therefore subject to no other change than that which is produced by external agents. When I began, in reference to this subject, to examine the differences of colour between the summer and the winter dresses of many of our native birds, I was led to conclude, from seeing feathers in all the intermediate shades of colour, that in many species there must, in the course of the year, be five or six different moultings, or that the colour changed while the feather remained. Upon searching for proofs of such frequent moultings, I not only was unsuccessful, but by observing feathers in progress to their destined colour, I abandoned the former opinion, while I embraced the latter. In hopes of being confirmed in my views by the communication of new facts, I stated my opinion on the subject to the late George Montagu, Esq. than whom, since the days of Willoughby, no one has examined, with so much care, the characters and economy of our British birds. I was disappointed in finding him prejudiced in favour of the old opinion, and disposed in some cases to admit, in the same bird, three successive moultings in the course of a year. In his letter, dated "Knowle, 7th December 1814," he adds, "But I have no conception of a change of colour in the same feather or the same hair, (because the colouring matter has been disposed in embryo), except by length of time, as our hair is changed by age." When I prepared the article *Hybernation of Animals*, which was printed, in 1817, in the eleventh volume of the Edinburgh Encyclopædia, conducted by Dr Brewster, I endeavoured to collect the proofs of the truth of my own views on the subject, and succeeded in at least convincing myself that they amounted to demonstration.

In the thirty-third article in the volume to which I have alluded of the Linnean Transactions, the subject is likewise brought forward. It is entitled, "Remarks on the Changes of the Plumage of Birds. By the Rev. William Whitear of Starston in Norfolk. Communicated by Joseph Sabine, Esq. F. R. S. and L. S. Read April 6. 1819." In this paper the author, evidently unacquainted with my observations and conclusions on the subject, published nearly three years before, states, "But no writer, with whom I am acquainted, has hitherto pointed out the fact, that in some birds *the full grown feathers themselves change colour, without being replaced by new ones*." And afterwards he adds, "On the 9th of January last, I received a young wild mallard, which had nearly assumed the plumage of the adult bird. Upon examining the feathers of this bird, I found many of them which were party-coloured, the same individual feather retaining, in some parts, the colours of the bird during its first months, and in other parts exhibiting those of the perfect bird," p. 525. Other facts of a similar kind are likewise recorded, as having been observed in the chaffinch, sandpipers and gulls.

In the valuable "Memoir on the Birds of Greenland," by Captain Edward Sabine, which follows the communication of Mr Whitear in the volume, there is added, under the *Alca alle*, some very interesting information regarding the change of colour which its feathers undergo. "The whole of the birds in the breeding season (the sexes being alike), had the under part of the neck an uniform sooty-black, terminating abruptly, and in an even line against the white of the belly: the young birds, which we saw in all stages from the egg, as soon as they were feathered, were marked exactly as the mature birds; but in the third week of September, when we were on our passage down the American coast, every specimen, whether old or young, was observed to be in change; and in the course of a few days, the entire feathers of the throat and cheeks, and of the under part of the neck, had become white," p. 537. I am the more pleased with the details of the change of colour in the plumage of this bird, because my attention was first directed to the subject, in consequence of comparing a specimen in its summer dress, which I received from that accomplished navigator Captain Scoresby, with those which I obtained in their winter and spring dress in Zetland. Montagu has indeed availed himself of the facts which I thus ascertained, in his supplement to the Ornithological Dictionary, article Auk, Little, 1813, and other details are given in the article HYBERNATION, Edin. Encyc. vol. xi. p. 388. 1817.

Neither Mr Whitear nor Captain Sabine have offered any conjectures in illustration of the laws which regulate these changes of the colour in the plumage of birds, and of the purposes to which they are subservient in the animal economy. In the article Hybernation referred to, I arrived at the following conclusions:

1. That this change, when it takes place in spring, is from a light to a dark colour, and that in autumn this arrangement is

reversed. Hence it follows, that in those animals in which a change of colour takes place, without a change of covering, the winter dress will always be found pale or white coloured, while the summer dress will be bright or dark. There is one remark, however, made by Captain Sabine, while treating of the Larus glaucus, which appears to militate against this law: "In winter, the mature bird has the head and neck mottled with brown, as is usual with all the white-headed gulls. In the perfect summer state, the whole plumage is white, excepting the back, scapulars, and wing-coverts, which are a very light ash colour," p. 544. But as the observations which led to this remark were made on stuffed specimens, it is possible that neither the age of the individuals, nor the periods at which they were shot, have been accurately recorded. In a domesticated state, Montagu observed the heads of the Larus canus and fuscus become mottled during the winter season, and resume their white state in the spring; but it remains to be determined if similar changes are effected in a wild state, where the quantity of food and the shelter are so very different. The scepticism which we are here disposed to entertain, is sanctioned by the observations of ten years attention to the subject, and even by numerous remarks, which occur in various other parts of the paper. We trust that Captain Sabine will not censure our caution as originating in a regard for a favourite hypothesis, since we can assure him, that the discovery of truth is our only object, and that the value of our conclusions is estimated by the strength of the proofs by which they are supported *.

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* We are disposed to request much stronger evidence than *opinion*, in the absence of any direct proof or analogy, before we admit that the black markings of the primary quill-feathers of the herring-gull, which endure the severities of a European winter, vanish altogether as the effect of climate in the summer of Greenland. Yet Captain Sabine, on the authority of Mr Temminck, regards the Silvery gull with white primary quill-feathers, as the mature Greenland summer dress, and the mature European winter dress, of the Herring-gull. If this is really the true state of the case, we would ask, What is the mature European summer dress of the Larus glaucus? Has it ever been found with black markings on the primary quill-feathers? This last species of gull is alluded to by Captain Sabine as a British bird. In the spring of 1818, Mr Bullock, whose valuable additions to the list of British birds are well known, shewed me a specimen of one which he had obtained from Zetland, and informed me that others had been shot at the mouth of the Thames and

2. That these changes of colour are regulated by the temperature of the atmosphere, the dark deep tints occurring during the heat of summer, the light-coloured ones in the cold of winter. "This supposition is countenanced by the slowness of the process of change of colour in a mild autumn, and its imperfect accomplishment during a mild winter. Besides, in some animals, such as the black guillemot, the change is never complete in the more temperate regions, but becomes more perfect as we proceed northwards, until at Greenland the bird is of a pure white." In attending, therefore, to the plumage of birds in reference to this subject, the mildness or severity of the season should likewise be considered. By attending to this law, the ornithologists may detect many spurious species in the modern lists of British birds, even after the successful labours of Montagu to elucidate the subject.

3. That these changes assist in regulating the temperature of animals in the different seasons of the year. It is generally supposed, that many animals become white in winter, in order to enable them to escape the observation of their foes, being nearly of the same colour as the snow. In reasoning concerning final causes, we should be careful to draw our conclusions from a minute and impartial view of all the circumstances of the case, lest we attempt to establish laws, whose operation would produce pain or ruin, where we intended to unfold the marks of wisdom and benevolence. It is obvious in this case, that while the ptarmigan and alpine hare would be protected from danger, the eagle, the cat, and the fox, would be in danger of starvation and death. But the fallacy of this popular opinion may be demonstrated from the circumstance, that the defenceless and the rapacious, the terrestrial and the aquatic animals, are equally subject to the change; and that the order of succession in the shades of colour is always the same, however different the habits or stations of the animals in which it is observed. The following explanation was offered of these curious phenomena of the animal economy: "If the radiating power of bo-

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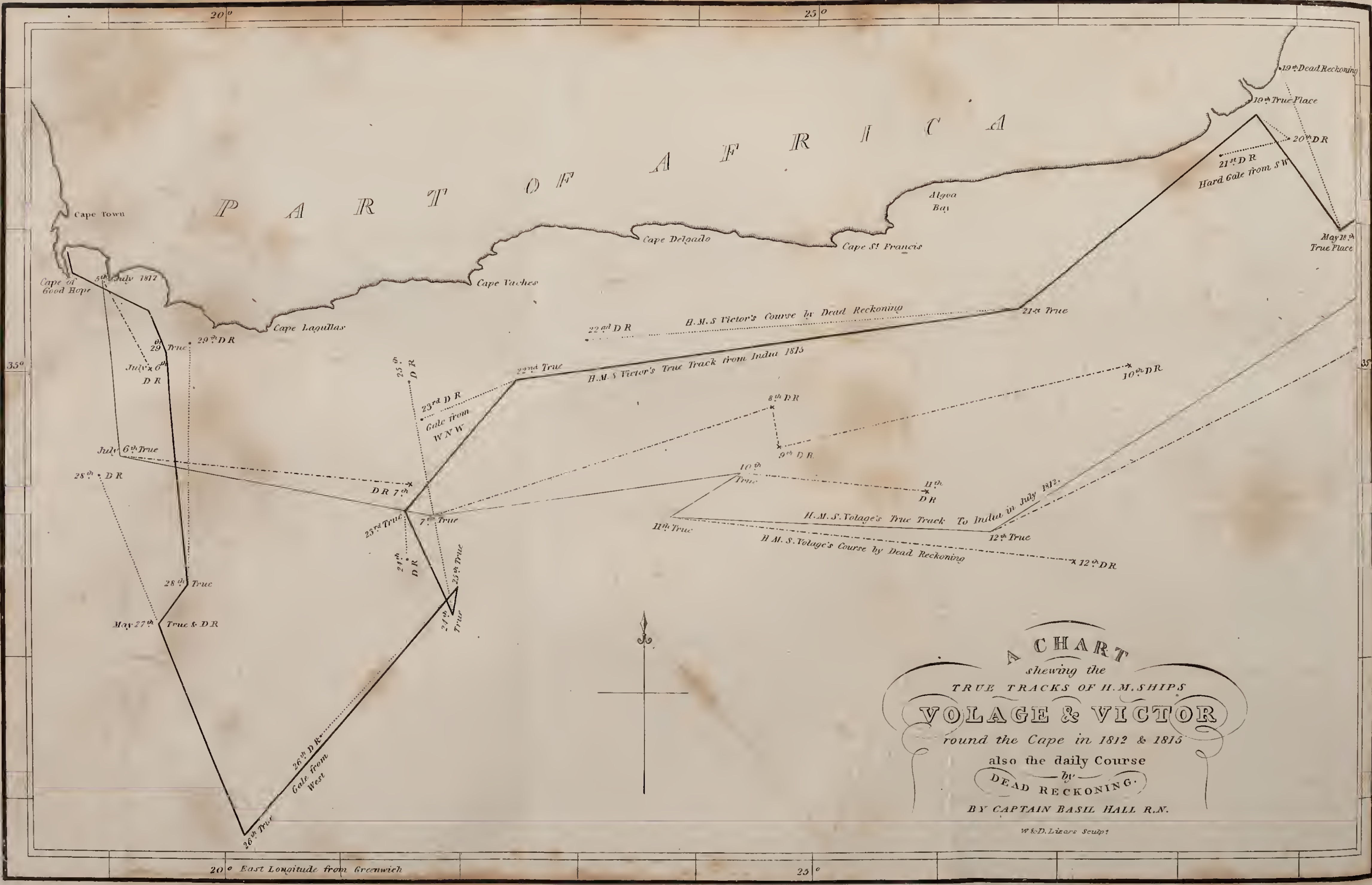
at Sunderland. In a letter which I received from him about eight months ago, he stated, that he had received another specimen from the Rev. Dr Stuart of Luss, which had been shot upon Loch Lomond.

dies with regard to heat be inversely as their reflective power, a conclusion very generally admitted, then the white winter dress of these animals must be better calculated for retaining the heat generated in their bodies by the vital principle, than any other coloured dress which would possess greater radiating power, and, consequently, would more readily contribute to the reduction of their temperature. Is it not in consequence of the same arrangement, in reference to temperature, that many old and young animals are pale coloured, and that the hair which grows from a part that has been wounded, is always whiter than the covering of the sounder parts?"

MANSE OF FLISK,
December 5. 1819.

Note by Professor JAMESON.

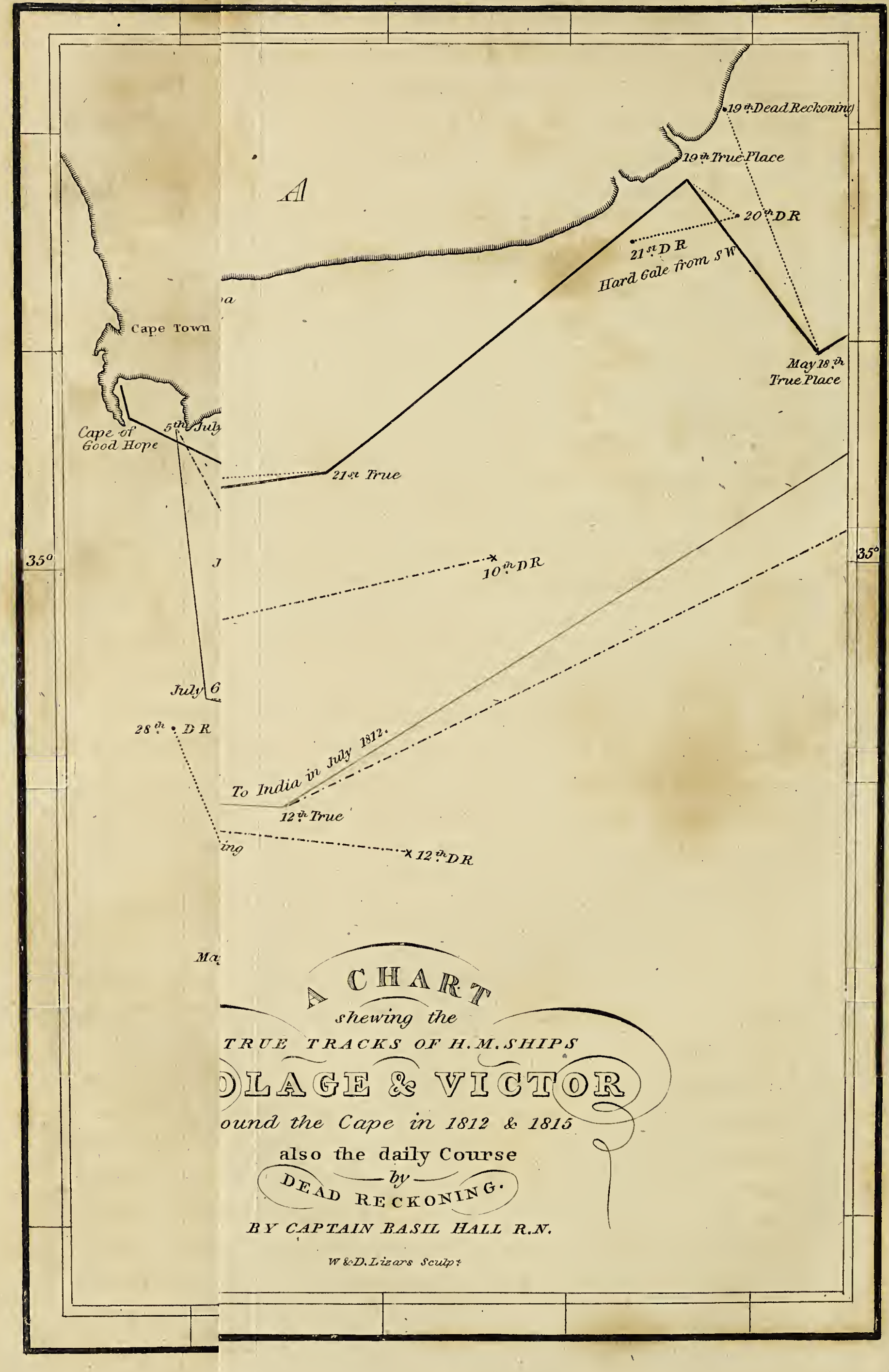
In reference to the preceding paper, we have to remark, that Mr Whitear does not appear to have known that the fact in regard to the change of the colour of the feathers of birds is not new, having been published in the year 1792, by Captain Cartwright, a gentleman long resident in Labrador; and my friend Dr Fleming also being unacquainted with Cartwright's statement, has fallen into the same mistake. For the information of our readers, we subjoin the following extract from Cartwright's Journal, (3 vols 4to, Newark, 1792), which contains his observations on this subject, and which proves not only the change of colour in the feathers, but also that an additional quantity of feathers is formed on approach of winter: "28th September 1773.—This morning I took a walk upon the hills to the westward, and killed seven brace of grouse. These birds are exactly the same with those of the same name in Europe, save only in the colour of their feathers, which are speckled with white in summer, and perfectly white in winter, (fourteen black ones in the tail excepted) which always remain the same. When I was in England, Mr Banks (now Sir Joseph Banks), Doctor Solander, and several other naturalists, having inquired of me, respecting the manner of these birds changing colour, I took particular notice of those I killed, and can aver, for a fact, that they get at this time of the year a very large addition



A CHART
shewing the
TRUE TRACKS OF H. M. SHIPS
VOLAGE & VICTOR
round the Cape in 1812 & 1815
also the daily Course
by
DEAD RECKONING.
BY CAPTAIN BASIL HALL R.N.

W & D. Lizars Sculpt

Edinburgh Published by A. Constable & Co. 1820.


19th Dead Reckoning
19th True Place
20th D R
21st D R
Hard Gale from S W
May 18th True Place
A
a
Cape Town
Cape of Good Hope
5th July
21st True
35°
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A CHART
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of feathers, all of which are white; and that the coloured feathers at the same time change to white. In spring, most of the white feathers drop off, and are succeeded by coloured ones; or, I rather believe, all the white ones drop off, and that they get an entire new set. At the two seasons they change very differently; in the spring, beginning at the neck, and spreading from thence; now, they begin on the belly, and end at the neck. There are also ptharmagans in this country, which are in all respects the same as those I have killed on some high mountains in Scotland." Vol. i. p. 278.

Art. XI.—*On the Proper Method of laying down a Ship's Track on Sea Charts, with some Remarks on the Importance of Time-keepers in Navigation.* By Captain Basil Hall, R.N. F.R.S. Lond. & Edin. Communicated by the Author.

There is no point in practical navigation of more importance, than the allowance for the direction and velocity of currents; and although the introduction of time-keepers and lunar observations has led to much more accurate methods of making this estimate, yet there is unquestionably still much obscurity belonging to this branch of the subject. And although it is scarcely to be hoped that we shall ever arrive at a correct knowledge of the laws which regulate the great streams of the ocean, we may certainly hope to approach much nearer than we are at present to the true state of the facts, and that we shall eventually be able, in the practice of navigation, to make much juster allowances than we now do for the influences of these powerful agents.

Probably much of the obscurity which belongs to this subject, arises from the inaccurate way in which the tracks of ships exposed to the influence of currents have been laid down on our charts; for the method most in use has this essential defect, namely, that on inspecting the chart of a preceding navigator, it is rarely possible to discover where any current began, where it ceased to act, what was its direction, or what its velocity,—all essential points.

The mode proposed in this notice answers all these questions, and is quite as easy in practice as that in most general use. It is so obvious, that I cannot help being sure that it must have occurred to many practical navigators; but as I have never met with it in any treatise on navigation, and have never seen a single chart in which the tracks were so laid down, I trust this notice will not be considered superfluous.

The common method is as follows: The ship's place of each day, as estimated from the log-board, is noted on the chart; and also the place, as deduced from chronometers and lunar obervations. The first is called the Place by Dead Reckoning, the other the True Place. The line joining the true places at noon is called the True Track; and that joining the others is called the Track or course by Dead Reckoning. As it happens invariably, that these two tracks separate very early in the voyage, and never afterwards come together, unless by accident, it is obvious, that, upon inspecting the chart, no information will be afforded as to the point where the current began, or where it ceased, or what was its set, or its velocity: all that we see is, two tracks wandering apart from one another, and it always requires some calculation and measurement to come at any thing like an estimate of the true effect of the current.

The tracks laid down on some of Mr Arrowsmith's maps of the Atlantic, are on this account altogether useless, although inserted expressly to show the effect of the current. And I speak from experience when I say, that a chart marked in this manner, whatever attention may have been paid to it by the navigator, leads only to confuse, and not to instruct.

The method which it is proposed to substitute, is this: Let the true place be laid down each day as before, either at noon, or, which is better, at the precise moments of observation for the longitude. Let a fresh departure be taken from every such true place so noted in the chart; and whenever a true place is marked on the chart, let the place by dead reckoning at that moment, *estimated by log-board from the last true place*, be also noted down. From each true place let two lines be drawn, one to the next true place, and the other to the dead reckoning place at the same moment.

It will follow from this, that the true course of the ship will be one continued unbroken line; but the dead reckoning course will be a series of terminated lines running off from the successive true places. The advantages of this method are these: In the first place, it will be evident that as long as there is no current, the true and dead reckoning places will coincide, and there will be but one line on the chart; but the instant that a current begins to act, the true and dead reckoning places will be different, and consequently the lines will separate: and whenever the current ceases, there will again be but one line. These distinctions catch the attention at once; but the plan has this farther great advantage, that the line joining the dead reckoning place and the true place, at any given hour, will express correctly the direction, and the set of the current, in the interval between the moment under consideration, and the instant of the last preceding observation.

It is useful, in practice, to have the line expressing the true course distinguished in some way from those marking the dead reckoning courses: one may be a strong black line, the others dotted lines; or when a chart is much covered with tracks, it is useful to use differently coloured lines. It is sometimes satisfactory to join the dead reckoning places and the true places by arrows, and then rub out the whole of the tracks; so that all which is essential, as far as currents are concerned, is retained, while all that is not, and which might tend to confuse, is removed.

When one or more days elapse without an observation, the dead reckoning track may be carried on till an observation be obtained, and then the dead reckoning place and the true place at that instant being noted, a knowledge of the strength and direction of the current during the interval, is at once afforded.

On the chart, Plate VIII. which accompanies this notice, there are two tracks of ships off the Cape of Good Hope, which will render what has been said quite clear.

It may be said that there is a fallacy in supposing the places, as laid down from chronometers and lunar observations, to be the true places: to which I would answer, that although it is not strictly the *true* place, it is generally not far from it; and for all practical purposes it may be so considered, because the object is, to ascertain the difference between the true path, and the dead reckoning path from day to day; and it must be a very bad chronometer that will not give this within an inconsiderable quantity. Thus a chronometer, which might give the longitude half a degree wrong at the end of an Indian voyage, would serve very well to estimate the daily effect of the current off the Cape of Good Hope, within half a league of the truth.

It is clear, that to a ship navigating without a chronometer or lunars, the above method is of no avail: even if frequent lunar observations be taken, still it is not possible to make the required comparison from day to day without chances of great error; whereas by means of a chronometer, (aided as it may very readily be by lunars), nothing is so simple.

In this age of science, of general intelligence, and of liberality in every thing connected with mercantile enterprise, it is indeed most astonishing, that any ship should ever be permitted to set out on any voyage without a chronometer: and owners of ships, independently of the fearful responsibility which they incur by neglecting so important a precaution, may be assured that they most materially neglect their own interest by this species of economy; for the safety of a ship is not only greatly lessened, but the voyage is, in nine cases in ten, materially protracted by the want of this easy and cheap addition to her equipment. Not only, therefore, the high obligation which they are under, to preserve, as far as in them lies, the lives of people embarked in their service,—but their own obvious pecuniary advantage, calls upon them to despise this paltry saving, and never to suffer one of their ships to leave port without being provided with an instrument often of as much value as either sails or rudder.

The class of navigators and ship-owners who, not many years ago, held scientific navigation in contempt, is now happily much reduced. On such persons well established facts have more influence than any general reasonings or assertions, and I beg leave to call their attention to the following circumstances which actually fell under my own observation.

In May 1815, in his Majesty's sloop Victor, I arrived off the Cape of Good Hope, in company with a fleet of Indiamen, all of which were of course amply provided with excellent timekeepers. The Arniston, a large ship, and formerly an East

Indiaman, was also in company. She had been sent with troops to the Island of Ceylon, and was now returning with invalids to the number of several hundred, together with upwards of fifty women and children. From what circumstance, whether of ignorance, or mistaken and most culpable economy, I do not know, this ship was unprovided with a time-keeper, and therefore, though commanded by an active and intelligent seamen, she was not, owing to this single omission, at all in a condition to approach this coast, especially at such a stormy season, when lunar observations were scarcely to be hoped for, and when the current was most violent and irregular.

It was the daily practice to telegraph the longitude to the Arniston, and as long as the fleet kept together, no disadvantage was experienced by her having no chronometer. But we had scarcely reached the eastern edge of the bank of Lagullas, when a violent gale scattered the ships in various directions, and the unfortunate Arniston was left to shift for herself. By reference to the Victor's track on the chart which accompanies this notice, Plate VIII., it will be seen to what a variety of currents we were exposed, from the 18th to the 28th of May; in this interval we had moreover three heavy gales of wind; from which it will be obvious, that by dead reckoning alone, it was altogether impossible to tell the situation of the ship. In fact, on board the Victor, I found, that after making every allowance for currents, which the experience of others on this well known ground entitled me to use, the dead reckoning was still upwards of 100 miles from the truth. But, after all, these observations are a mere guess.

Meanwhile, the Commander of the Arniston, after making every possible allowance, conceived, at the end of ten or twelve days, that he must have passed to the *westward* of the Cape of Good Hope, by a very considerable distance, and without hesitation, bore up with a south-easterly gale of wind, and steered, as he thought, for St Helena. He had not proceeded, however, many hours, before the land was discovered a-head, and on each bow; they were embayed, in short, a hundred miles *east* of the Cape, and though they let go their anchors and cut away their masts, the gale drove them on the coast, and of the whole crew, soldiers, women, and children, only four or five sailors reached the shore alive!

In order to prove that this ship was lost for want of a time-keeper, it is only necessary to state the following facts, which will be conclusive with every practical navigator.

By means of good time-keepers, I found that his Majesty's sloop Victor, during the interval above mentioned, was carried by the current 186 miles to the westward, and 72 miles to the eastward, making an aggregate of 114 miles, or 2° 18′ of westing more than the dead reckoning. Now, it would have been a moderate allowance for the effect of the Cape current, under all the circumstances of the case, to have supposed the ship to be set to the westward in eleven days, at least 220 miles, or 106 miles more than the ship was actually set. So that after the Commander of the Arniston had made all the usual allowances, he would still have estimated his place wrong by at least 106 miles, or 2° 8′ of longitude, an error five times greater than the worst chronometer I have ever seen in use, would have given in so short an interval. It thus becomes certain, that when the Arniston was, by dead reckoning, after full allowance had been made for current, apparently many miles west of the Cape, she was in fact a very long way east of it. And the important circumstance to be borne in mind is, that had this ship been provided with a very ordinary chronometer, costing from 60 to 100 guineas, she would, according to every principle of navigation, most assuredly not have been shipwrecked.

ART. XII.—*Account of a new Arrangement of the Algæ by* H. CHRIST. LYNGBYE.

THE Algæ or true aquatic plants, including the various tribes of Fuci, Ulvæ, Confervæ, and Tremellæ, form a very beautiful department of the botanical system. Of late years, much attention has been bestowed on the investigation of their structure, physiology, and distribution; and many curious facts and arrangements of Nature have thus been brought to light.

Their systematic arrangement, which appears to be attended with many difficulties, has been greatly studied by naturalists since the time of Linnæus and Gmelin, but hitherto no satisfactory method has been proposed. Dr Walker, late Professor of

Natural History in the University of Edinburgh, who was particularly attached to the study of this series of plants, conceived and executed a systematic arrangement of them in the year 1771. In his method, the whole are divided into fourteen genera, and the generic characters, which are founded partly on the fruit, and partly on the forms and structure of the species, possess considerable merit *. In 1793—1797, Stackhouse published an arrangement of Fuci, in his work entitled Nereis Britannica; and in 1816, in a new edition of the same work, the system is extended, by the addition of numerous new genera. The first edition of the Nereis Britannica contained curious observations, and good figures, of several rare species; but in the new edition, unfortunately, the figures are miserable, and unworthy a British artist. The whole family is there divided into thirty-five genera; but these do not appear to be constructed on any fixed character or series of characters. This work, therefore, although it contains interesting observations, cannot be commended for its systematic arrangement. The industrious Roth, the celebrated Decandolle, and the enterprising and enthusiastic Wahlenberg, have also attempted to form the fuci into genera, but unsuccessfully. Lamouroux, an ingenious French naturalist, has lately published an arrangement, in which he uses the fructification, and also various characters drawn from other parts of the plant, or even from any remarkable accessary circumstance. This method, with all its intrinsic merits, we consider as too artificial, and too complicated, and therefore not likely to be adopted by botanists. In the year 1817, Charles A. Agardh, Professor at Lund in Sweden, published a work entitled, "Synopsis Algarum Scandinaviæ, adjecta dispositione universali Algarum." He employs in his generic characters, not only the seeds, but also the whole habit of the plant. In this arrangement, the Algæ are subdivided into the following *sections*. 1. FUCOIDEÆ, which contains seven genera. 2. FLORIDEÆ, seven genera. 3. ULVOIDEÆ, nine genera. 4. CONFERVOIDEÆ, seventeen genera. 5. TREMELLINÆ, five genera. Acknowledging as we do the excellence of Agardh as an observer, we cannot help feeling, that his system wants that certainty and distinctness which is required in all works of this description.

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* For an account of Dr Walker's arrangement, we refer our readers to Neill's luminous and interesting account of the Fuci, in the *Edinburgh Encyclopædia.*

But the most scientific and satisfactory arrangement of the Algæ hitherto proposed, is that of H. Christian Lyngbye, author of a most valuable work, in 4to, printed at Copenhagen in 1819, at the expence of the King of Denmark, under the title of "Tentamen Hydrophytologiæ Danicæ; cum Tab. æn. 70." It contains the results of numerous journeys, and of long, patient, and careful investigation. The arrangement, which is all that interests us at present, is founded on the seeds, and on differences in the form and structure of the plants. The following view of the arrangement, with the character of the Orders (*Sectiones*) and Genera, we have no doubt will prove very acceptable to our botanical readers.

HYDROPHYTA.

A. Frondosa.
a. Continua.
α. Solida.—Sect. I. Phycoidata.
a. a. Fronde plana.

1. *Fucus.* Frons plana dichotoma olivacea. Receptacula terminalia, turgida intus mucosa, tuberculis numerosis sphæricis fibrisque intertextis repleta.

2. *Delesseria,* Lam. Frons plana membranacea costata rosea. Semina nuda frondi immersa, vel tuberculosa globosa innata. (F. sanguineus, sinuosus, et alatus.)

3. *Odonthalia,* Lyngb. Frons plana membranacea subecostata dentata rubra. Siliquæ axillares lanceolatæ. (F. dentatus.)

4 *Spærococcus,* Stackh. Frons plana membranacea ecostata rubra. Tubercula globosa ad marginem sessilia. (F. membranifolius, Brodiæi, palmetta, laciniatus, ciliatus, Turn.; cristatus, L.; mammillosus.)

5. *Chondrus,* Stack. Frons plana dichotoma vel ramosa rubra. Tubercula hemisphærica, apicibus frondis innata. (F. crispus, Norvegicus, rubens, L.; laceratus, Gmel.; Bangii, Fl. Dan.)

6. *Zonaria,* Draparn. Frons plana orbicularis oppressa. Semina nuda, in lineas transversales concentricas. disposita. (F. fungularis, Fl. Dan. 420.)

7. *Laminaria,* Lam. Frons plana stipitata olivacea, radice fibrosa. Semina nuda frondi immersa. (F. digitatus, bulbosus, saccharinus, esculentus, phyllitis, agarum, Turn.)

8. *Ulva.* Frons plana expansa. Semina nuda, substantiæ frondis immersa. (F. palmatus, L.; edulis, soboliferus, fascia, Turn.;

Ulva umbilicalis, L.; purpurea, Roth; lactuca, plantaginea, Roth; dichotoma, Huds.; linza, terrestris, Roth.)

b. b. Fronde compressa.

9. *Desmia.* Frons compressa ramosa. Fructus ignotus vel forsan in fibris e fronde prodeuntibus quærenda. (F. ligulatus, aculeatus.)

10. *Himanthalia.* Frons compressa dichotoma e basi cyathiformi erumpens. Tubercula numerosa per totam frondem sparsa. (F. loreus.)

11. *Halidrys.* Frons compressa ramosa. Receptacula turgida, intus mucosa, tuberculis sphæricis repleta, lateralia vel terminalia. (F. nodosus, siliquosus.)

12. *Ptilota.* Frons compressa ramosissima, supra decomposita. Capsulæ quinquefidæ, (F. plumosus.)

13. *Plocamium.* Frons compressa disticha ramosissima, ramulis ultimis pectinato-secundis. Capsulæ laterales vel semina nuda apici frondi immersa. (F. coccineus.)

14. *Gelidium.* Frons compressa vel angulata ramosa. Tubercula globosa terminalia. (F. pinnatifidus, gigartinus, pygmæus, Turn.)

c. c. Fronde tereti.

15. *Gigartina.* Frons ramosissima. Tubercula globosa, ad latera ramorum sessilia, externa, vel semina nuda interna. (F. plicatus, Griffithiæ, Turn.; confervoides, viridis, lycopodiodes, pinastroides, purpurascens, subfuscus.)

16. *Furcellaria.* Frons dichotoma fastigiata. Tubercula terminalia subulata vel lateralia spongiosa. (F. lumbricalis, rotundus.)

17. *Chordaria.* Frons teres. Semina nuda toti frondi immersa, eamdemque quasi constituentia. (F. scorpiodes, Fl. Dan.; flagelliformis, Rivularia multifida, Conferva paradoxica, Roth.)

18. *Thorea.* Frons teres, lubrica ramosa, filis articulatis undique obsessa. Fructus ignotus.

β. Fronde tubulosa.—Sect. II. SOLENIATA.

19. *Scytosiphon.* Frons continua membranacea, æqualis, simplex vel ramosa. Semina nuda, substantiæ frondis innata, solitaria vel aggregata. (Ulva sobolifera, Fl. Dan.; Batrachospermum hispidum, Decand.; Conferva fœniculacea, Huds.; Ulva compressa, Conferva clathrata, Roth; Ulva fistulosa, Huds.; intestinalis.)

20. *Gastridium.* Frons continua, subramosa, gelatinosa, interdum articulato-contracta. Semina nuda, substantiæ ramulorum immersa. (Ulva filiformis, Huds.; Fucus clavellosus, kaliformis, Turn.)

21. *Chorda.* Frons simplicissima. Semina nuda, in muco frondem ambeunte nidulantia. (F. filum.)

22. *Bryopsis.* Frons subpinnata. Granula minutissima in caule ramisque fistulosis nidulantia. (Bryopsis, Langbyi, Fl. Dan. 1603.)

23. *Vaucheria.* Fila capillaria continua plerumque ramosa, massa granulosa intus aspersa. Vesiculæ externæ globosæ. (Conferva dichotoma, frigida, Dillw.; Tremella granulata, Huds.; Conferva dilatata, Roth.)

24. *Bangia.* Fila capillaria continua. Granula elliptico-cylindrica vel globosa, intus congesta. (Conferva atro-purpurea, Dillw.; rutilans, Roth; atro-virens, Dillw. fœtida, Dillw.)

25. *Oscillatoria.* Fila continua membranaceo-herbacea, lubrica, intus hyalina vel striis transversalibus parallelis densis notata. (Conferva limosa, Roth; velutina, Roth; ochracea, Dillw. fontinalis, distorta, Fl. Dan.; majuscula, Dillw.; chthonoplastes, Fl. Dan.; confervicola, muralis, decorticans, Dillw.)

26. *Scytonema.* Fila continua coriacea, intus striis transversalibus annulatis vel moniliformibus notata. (Conferva myochrous, ocellata, comoides, Dillw.)

27. *Nodularia.* Fila continua simplicia majuscula, extrinsecus nodulosa. Semina cylindraceo-ovata, in statu dultiori libera, totum fili tubulum replentia. (Conferva fluviatilis.)

b. *Frons geniculata.*

α. Teres.

a. a. Solida.—Sect. III. STEREOGONATA.

28. *Lomentaria.* Frons teres subgelatinosa articulata contracta, ramis oppositis verticillatisque. (F. articulatus, Lightf.)

29. *Cladostephus.* Frons articulata ramosa, setis ad genicula verticillatus obsessa. (Conferva verticillata, Lightf.)

30. *Sphacellaria.* Frons articulata ramosa disticha. Semina nuda apicibus sphacelatis demum dehiscentibus inclusa: raro capsulæ. (Ceramium pennatum, Roth; Conferva scoparia, pennata, Dillw.; fusca, Huds.)

31. *Hutchinsia.* Frons articulata ramosa rosea: articuli striis vel tubulis pluribus longitudinalibus notati. Capsulæ externæ, vel tubercula apicibus ramulorum innata. (Conferva polymorpha, Brodiæi, Dillw.; byssoides, fucoides, Huds.; badia, Dillw.)

32. *Ceramium.* Frons dichotoma ramosa, rosea. Articuli reticulato-venosi vel subdiaphani. Capsulæ ramulis brevibus involucratæ. (Conferva elongata, Fucus diffusus, Huds.; Conferva rubra, Dillw.; diaphana, ciliata, Huds.)

b. b. Tubulosa.—Sect. IV. SIPHONIGONATA.

33. *Callirhamnion.* Frons teres articulata ramosissima rosea: articuli uno tubulo latiori longitudinali notata. Capsulæ ad latera ramulorum sub-pedunculatæ. (Conferva arbuscula, Dillw.; coccinea, Huds.; corymbosa, Eng. Bot.; corallina, rosea, plumula, repens, Rothii, Dillw.)

34. *Ectocarpus.* Frons articulata, membranacea ramosissima fusca. Capsulæ ovatæ siliquæformes vel racemosæ, ad latera ramulorum sub-pedunculatæ. (Conferva littoralis, siliculosa, Dillw.; tomentosa, Huds.; chalybea, Roth.)

35. *Bulbochæte.* Fila articulata membranacea ramosissima viridia, setis bulbiferis ad summitates articulorum instructa. Capsulæ sessiles laterales. (Conferva setigera, Roth.)

36. *Conferva.* Fila articulata membranacea simplicia et ramosa viridia. Granula in articulis sparsa. (Conf. compacta, Roth.; dissiliens, Dillw.; sordida, violacea, Huds.; ericetorum, Roth.; capil-

laris, rivularis, flacca, implexa, Dillw.; fucicola, Vell.; Linum, Fl. Dan.; aërea, ægagropila, crispata, Roth; fracta, sericea, glomerata, crystallina, rupestris, flavescens, nigricans, Roth; Wormskioldii, Fl. Dan.; castanea, Dillw.; velutina, umbrosa, Byssus iolithus.)

37. *Hydrodictyon.* Fila articulata membranacea, in formam articuli connexa, viridia. Embryo, matri similis, in quovis reticulo invaginatus. (Conf. reticulata.)

38. *Zygnema.* Fila articulata membranacea simplicia viridia, demum per tubulos breves transversales conjugata. Semina solitaria, singulis articulis post copulationem inclusa. (Conf. genuflexa, decimina, quinina, nitida, bipunctata.)

β. Frons plana.—Sect. V. HOMALOGONATA.

39. *Diatoma.* Fila articulata simplicia crystalliformia, immediate copulata, tandem articulis solutis angulo alternatim cohærentibus. Conf. flocculosa, Fl. Dan.)

40. *Fragilaria.* Fila articulata plana fragilia, articulis solutis angulo non alternatim cohærentibus. (Conf. striata, Eng. Bot.; lineata, Dillw.; pectinalis, Müh.)

B. GELATINOSA.—Sect. VI. TREMELLOIDATA.

41. *Batrachospermum.* Frons gelatinosa, articulata ramosa, ramulis ad genicula verticillatis. Capsulæ globosæ intra verticillos sitæ. (Conf. gelatinosa, atra, Huds.)

42. *Draparnaldia.* Frons gelatinosa articulata ramosa, ramulis fasciculatis penicilliformibus. Granula in articulis sparsa. (Conf. chara, Roth; mutabilis.)

43. *Mesogloia,* Ag. Frons gelatinosa elongata ramosa, filis e communi frondis axi exeuntibus ramosis, articulatis, capsuliferis farcta.

44. *Chætophora.* Massa gelatinosa elongata vel globosa, filis ramosis articulatis farcta. (Rivularia endiviæfolia, Roth; elongata, pisiformis.)

45. *Linckia.* Massa gelatinosa elongata vel globosa, filis simplicibus rectis acuminatis articulatis vel sub-continuis farcta. (Rivularia atra, angulosa, dura, Roth.)

46. *Nostoc.* Massa gelatinosa difformis vel globosa, filis simplicibus curvatis moniliformibus farcta. (Tremella Nostoc, verrucosa; Ulva pruniformis, pisiformis.)

47. *Alcyonidium.* Massa gelatinosa elongata ramosa olivacea, intus cellulosa, capsulas solitarias granuliferas includens. (Ulva diaphana, flavescens, Huds.)

48. *Palmella.* Massa gelatinosa subhyalina, granulis solitariis globosis farcta. (Batrachospermum myurus, Decand.; Byssus botryoides, L.; Tubercularia rosea, Pers.)

49. *Echinella,* Achar. Massa subgelatinosa, granulis solitariis cuneatis elongatisque farcta.

We cannot conclude this short notice, without expressing a hope, that our celebrated algist Dawson Turner, now that his great work on Fuci is finished, will be induced to publish his views in regard to their arrangement.

Art. XIII.—*A Method of determining the Height of Cliffs or Mountains, by measuring the Depression of the Horizon.* By William Scoresby, Esq. *junior*, F. R. S. E. &c. Communicated by the Author.

The determination of the height of cliffs and mountains, is an object of importance and interest to the geologist, meteorologist, hydrographer, and land-surveyor: hence, any practical mode of performing this operation in an easier or more familiar manner, either as to the mode of observation or calculation, than the methods now in use, may not be unworthy of attention.

Trigonometrical operations, and barometrical observations, are the principal means at present practised for the mensuration of heights. The former can be applied in very few situations, without considerable labour, the use of several instruments, and the employment of several assistants; and, after the necessary observations are made, a troublesome series of calculations is requisite, before the elevation of the situation can be determined. The latter, though easy as to the nature of the observations, requires a delicate, portable, and expensive barometer, and the use of at least two thermometers, and then does not afford any accurate result, without the application, to the observations, of a troublesome formula.

In the proposed method of measuring heights, the use only of a small sextant and an artificial horizon are necessary, with which instruments, after observations that may be made in five minutes are obtained, the height of the station above the level of the sea is found at once, by the simple inspection of a table. This method is, however, limited in its application, and is only calculated for situations from whence the sea, on the horizon, can be seen, and at such times (unless other instruments are used) as the sun, or other heavenly body, appears either within thirty degrees of the zenith, or in azimuth over the sea.

The necessary operation merely consists in finding the depression of the horizon from the point whose elevation is required. This may be effected, either by measuring the angle between a horizontal plane and the visible horizon by a dip-sector, (in which case the presence of the sun is not necessary), or by finding the true altitude of the sun, or other heavenly body, by means of an artificial horizon, and deducting this altitude from the angular distance, corrected for terrestrial refraction, between the sun and the visible horizon. The common tables of depression seldom going beyond 100 feet of elevation, a table for the mensuration of heights should be constructed, extending to 20,000 or even 30,000 feet. The semi-diameter of the earth, (or 21,000,000 feet), at the surface of the sea, being to the same increased by the height of the eye, as radius is to the secant of the depression of the horizon, this depression, at the altitude of 100 feet, would appear to be about 10′ 38″; at 1000 feet, 33′ 36″; at 2000 feet, 47′ 23″; at 3000 feet, 58′ 0′; at 4000 feet, 1° 6′ 30″; at 5000 feet, 1° 14′ 20″; at 10,000 feet, 1° 46′ 10″; at 20,000 feet, 2° 30′; at 30,000 feet, 3° 3′ 40″; at 40,000 feet, 3° 32′ 5″; and at 50,000 feet, about 3° 57′.

Hence, if we suppose, for example, on the top of a cliff, the height of which was required, that the sun's true altitude, by an artificial horizon, should be found to be 48°, and the altitude at the same instant (or the mean of two altitudes, at equal intervals before and after the same instant,) by the horizon, corrected for terrestrial refraction, should be 49° 6′ 30″, the difference, 1° 6′ 30″, would be the depression of the horizon, corresponding, as appears above, with an elevation of 4000 feet. An error of a minute in the depression, at this elevation, would be productive of an error only of 40 yards in the altitude; and at the height of 20,000 feet, the same mistake in the depression would produce an error not exceeding 86 yards.

This mode of determining heights, is applicable in all situations where the sea can be seen on the horizon, however distant, and is simplified in every case where the sun appears in azimuth above the sea, or, if over the land, with an altitude of 60° or upwards; so that, with a common sextant, it can be brought to the horizon on the opposite side of the zenith.

The only circumstance, perhaps, that will render the practice of this method in any way uncertain, is the variable nature of the terrestrial refraction. Whether an allowance in minutes of one-twelfth of the distance of the horizon in miles, (the mean effect at equal altitudes), combined with the refraction produced by the diminished density of the atmosphere, will afford an accurate correction, a few trials may be necessary to determine. Such trials besides showing the degree of reliance that might be placed on this method of ascertaining elevations, would likewise be useful in determining the nature and extent of the changes in the refractive property of the lower atmosphere,—a subject of most essential importance in various trigonometrical operations.

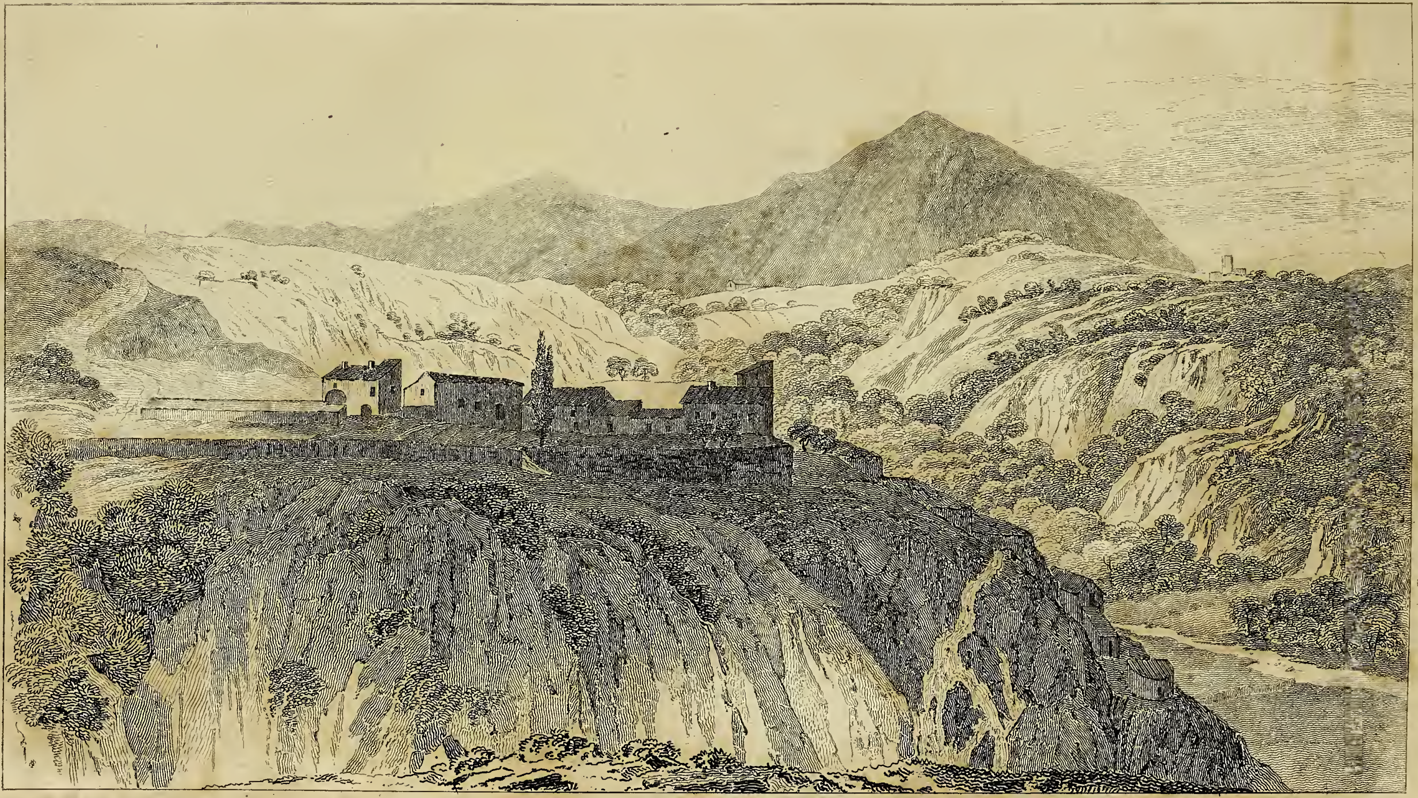
Liverpool, *30th November* 1819.

Art. XIV.—*Account of a Visit made to the Baths of St Filippo in Tuscany, with a Description of the Mode of forming Stone Medallions in Basso Relievo from the Waters of the Spring.* In a Letter from Dr Gosse of Geneva, to Professor Jameson.

In compliance with your request, I have great pleasure in communicating to you an account of a visit I made in the year 1818 to the baths of San Filippo in Tuscany. I enclose also a hasty sketch I made of the surrounding country, and shall subjoin a few details of the curious manufacture of stone-casts, which has for many years been established there. I regret that the shortness of my visit renders my account much less complete than I could wish, but, in the absence of better information, it may perhaps be acceptable to your readers.

On the morning of the 21st February 1818, I set out from Sienna, and, proceeding through a country consisting mostly of blue argillaceous soil, mixed with sea-shells disposed in hills of slight elevation, I reached, towards evening, the foot of Mount Amiata, from which the springs that supply the baths originate. As we approach the mountain, the features of the country become more rocky, and the mountain itself exhibits the characters of an extinct volcano, of which more particular details may be found in a descriptive tour made several years ago by Professor Santi of Pisa. The height of the mountain is very considerable, and therefore it is seen from a great distance, to the west of the road leading from Sienna to Rome. Having travelled some miles by the side of its base, I reached at length the torrent of

PLATE IX.



Drawn & Engraved by W. H. Lizars From a Sketch by Dr. Gosse

VIEW OF THE BATHS OF St. FILIPPO.

Edinburgh Published by A. Constable & Co. 1820.

the Urcia, which descends from it. Over this torrent a bridge is built; and just above it, rises a small rocky hill to the height of 80 or 100 feet, the summit of which is flat, and stretches towards the mountain. Proceeding a few hundred yards along this *plateau*, in the direction of the mountain, we come to the *Bagni di Vignone*, which, as medicinal baths, are scarcely less celebrated than those of *San Filippo.* The water supplying these baths rises up in two or three different parts of the middle of a large square pond: it has the appearance of water in a state of ebullition, and is raised in successive gushes, with a deep rushing sound, in columns of one foot in diameter, and to the height frequently of two feet above the surface of the pond. Its temperature is sufficient to boil eggs, and it is often applied to that and similar uses. The buildings for the baths are situate to the south, near the exit of the pond, and are well adapted to their intended purpose. The patients who resort thither during the summer, find accommodation in the small village that in part surrounds the pond. This water contains a large portion of calcareous matter, which forms considerable depositions in its course. In proof of this I may mention, that a small mill, erected near the bridge over the Urcia above mentioned, and worked by the water of the springs, has become entirely encrusted with this matter, so as to stop the machinery. The presence of iron is also manifested in this water, by the depositions of ochreous matter; but it seems to be entirely free from sulphureous impregnation, which remarkably distinguishes it from the waters of San Filippo.

Night approaching, and being unable to procure accommodation at the village, I was obliged to proceed to the inn of La Scala, a distance of about four miles.

The next morning I set out for the *Bagni di San Filippo*, situated at about nine miles distance from the place where I had spent the night. The country through which I walked, assumed a wilder character as I proceeded; the valleys were deeper, and the rocks loftier and more picturesque. At the distance of six miles I reached the village of Campiglia, situate on the declivity of the mountain, and surmounted by rocks on which stood the Castle of Campiglia, belonging to the Counts of that name. From this spot the road to the baths is continued by the side of the Rondinaya, a mountain torrent that rolls its waters along a narrow valley. Proceeding up this valley for about three miles, I came in sight of the *Bagni di San Filippo,* situated in a large valley opening to the right. The ground on which the baths are placed is considerably elevated, and to the eye presents a white rounded surface, lying to the south-east of the Amiata, the summit of which, from this spot, appears at not less than three miles distant. Stretching south is a range of mountains connected with the Amiata, and forming its back-ground. The elevated site of the baths is near to a mountain called *Il Zoccolino,* at the foot of which flows a rivulet or small torrent, that falls into the Rondinaya, near a bridge named Ponte Termone. Quitting at this place the high road which leads to Radicofani, and following the course of the small torrent above mentioned, the bed of which appears white from the deposition of calcareous matter, we arrive at the hill on which the baths stand. Its direction is east and west; its height above the torrent between 250 and 300 feet; its breadth about 300 paces; and its length a quarter of a league. It seems to be composed, at least in its upper part, entirely of the white calcareous matter afforded by the hot-springs. The opposite side of the rivulet I did not visit. It is covered with trees, and is said to be composed of a yellowish-brown, or greenish coloured argillaceous stone, easily acted on by water, and similar to that often found in this country in the neighbourhood of extinct volcanoes.

The village of San Filippo is situated on the east side of the declivity of the hill. The spring which supplies its baths is the least abundant, and issues into day immediately behind the village, on its northern side, to which place it is conducted by subterraneous channels from the western side of the hill. The column of water is about 9 inches in diameter, and its temperature rises to about 40° Reaum. or 122° Fahr. It falls into a pond, constructed about twenty years ago, where it has since deposited a solid rounded earthy mass, more than 30 feet thick; from this place it is conducted to work a mill belonging to the surrounding villages. A second spring lies to the west of the village: it runs directly into the torrent without being employed: its temperature exceeds by a degree or two that of the former. Besides these two springs, there is a third on the top of the hill, which has formed for itself a small pond. It is as warm as the others, and is supposed to communicate with them.

When the water of these springs first issues from the earth, it is limpid and transparent, but soon assumes a yellowish pearly hue, has a strong hydrosulphurous smell, and abundant vapours arise from it. According to Professor Santi, it yields much carbonic acid gas, when submitted to heat, and contains sulphate and carbonate of lime. Sulphate of magnesia and sulphur are also to be found in the depositions, which are rapidly and abundantly formed by the cooling of the liquid. Notwithstanding the high temperature of these springs, *confervæ* grow in their currents; they have a dark green colour, are of a gelatinous texture, and sometimes covered with a light whitish earthy crust, and with numerous vesicles containing air. When dried, they take on a bluish tint, and afterwards, by exposure to air, become colourless.

Towards the bottom of the north side of the hill, near to the torrent, is a fourth small spring, named Acqua Santa, the water of which differs materially in quality from those above mentioned. It is transparent, and affords no deposit; its temperature is low, and the taste like that of diluted sulphuric acid.

The soil around these hot springs is formed of matter deposited by them: it is more or less white or grey, and more or less hard and porous. Its surface, in some parts presents traces of channels, formed by small currents of water, which no longer exist. In other parts, particularly near the second spring, there are deep fissures in the surface, the consequence of an earthquake. One of these fissures is 30 feet deep, and from 150 to 200 feet long. Its shape is irregular; its sides perpendicular; in some places it is many feet wide, and in others so narrow, as to be easily jumped over. The water in it has a whitish colour, is in a state of ebullition, (whence the name of Il Bollore, by which it is designated), and copious vapours of steam and sulphur arise from it. Other cracks have given rise to large cavities, in which the sublimated sulphur is deposited in a crystalline form, in the same manner as in the Solfaterra near Naples. The separation of the sulphur was formerly a branch of industry, which has lately been abandoned.

The surfaces of these fissures are also penetrated by sulphuric acid, which renders them sour to the taste.

Few vegetables grow on this soil. Small shrubs of *Buxus sempervirens*, or a few grasses only, are distributed over its surface, and the leaves of the *buxus* have all a yellowish-brown colour. The northern declivity, particularly in the course of the rivulet, is thickly covered with vegetables and small trees. The soil here is of a dark colour, the result either of vegetable decomposition, or of the different nature of the earthy substances that compose the lower part of the hill. Vineyards have not succeeded near the village, even in transported soil; which seems to arise from the baneful emanations diffused through the air, rather than from defects in the soil.

The west end of the hill has a rounded form, and is separated from the neighbouring mountain by the small torrent above mentioned, the bed of which is filled with calcareous rocks from above. Crossing by a small bridge the rivulet at this part, the appearance of the surface is entirely different. Large masses of the calcareous deposit called Travertino, 20 or 30 feet thick, presenting sharp edges, and spread in all directions, indicate the existence of an ancient spring at a greater height. In going 100 yards higher up the mountain, the travertino is found in regular layers, which seem at one time to have been joined with those of the hill below. At this part I met with the siliceous stalactites discovered by Professor Santi; they have a mamillary form, a pearly colour, are shining and semitransparent, and cover the lower surface of the layers of travertino to the thickness of ⅛th of an inch. The travertino of St Filippo is not very porous, but hard, and resists the destructive action of time and weather. It is of a greyish colour outside, but when broken has a whitish and somewhat shining appearance. Carbonate of lime enters principally as its component, and the presence of silica is not to be denied, at least in some parts of its surface, as appears by what we have already mentioned. It belongs to the ancient water deposits of hot springs in Italy, which, I have observed, seem in general to have a different composition from those of recent date, being more dense, more solid and abundant. In some other places where travertino is found, the warm springs have disappeared, or those which yet exist have ceased to deposit earthy matter.

This travertino is similar to that found at the bottom of the eastern side of the mountains, near to Chiusi, 12 or 15 miles distant, and to that also in the neighbourhood of Rome, which was employed by the Etruscans in the construction of their buildings and sepulchral monuments; and both in ancient and modern times has been very extensively used for similar purposes by the Romans.

Vegetation is very luxuriant among the rocks of travertino. Large chesnut trees, intermixed with the humbler plants, spread widely up the mountain, and give it a very picturesque appearance. In one of the wildest and most isolated parts, is a place held in great veneration, named the Hermitage of St Filippino. It is a retreat or dwelling established beneath a large rock of travertino. On the door is inscribed: *Questo liocho fu dificato da Rhabone ribellato.* It derives its name from St Filippo, a Florentine, who withdrew from the world and hid himself there for three months, to avoid, it is said, his election to the Popedom, when Gregory Xth was raised to that dignity.

The village, named after this humble recluse, is small, and has a miserable appearance. The houses are ill constructed and badly kept: the church also is dedicated to, and contains many relics of the saint. It belonged from the eighth century to the Abbey of St Salvador del Montamiata; was then taken possession of by the Lords of Campiglia; afterwards by the Republic of Sienna; and, lastly, was comprised in the Grand-dukedom of Tuscany.

From the most remote periods, San Filippo has been famed for its mineral waters. The nations of Etruria used them, and the Romans constructed baths there, as appears by the medals occasionally found, and by the remains of some Ionic columns, reticulated walls, &c. These were afterwards destroyed, and subsequently covered by earthy depositions. In the 14th century they were again rebuilt and destroyed; and at a later period, the Grand Duke Ferdinand having used them with advantage in a painful chronic affection of the head, this cure has been transmitted to posterity by an inscription still existing in the village, in the following words: "Ferdinandus II. Magnus Dux V. dum adversa valetudine laboraret, thermis hisce capitis languore depulso, bene convaluit: Lælius Gulielmus, ob restituti Principis gloriam, hoc egregiæ medelæ monumentum posteris excitavit, A. D. 1635." At present two small rooms are the only places in which the water is employed in the form of baths, and of *douches* or in stream. The price of the baths is moderate, and the administration of the douches does not increase the expense. The number of patients is not so great as at the Bagni di Vignone, but seems increasing, from the reputation the water possesses in rheumatic and cutaneous affections, and in some species of tumours and ulcers. The water of the warm springs is not administered internally; the Acqua Santa being preferred for that purpose, as an excellent solvent in calculous diseases. The peasants also use the cavities, in which the sulphur sublimes, as vapour baths, and speak highly of their efficacy. I had no opportunity of witnessing the application of the baths, nor of conversing with any physician about them; but if I may judge by their temperature, they must possess the same advantages as other hot springs in Italy, of which the effects have been well described,—as those of the Baths of Lucca by Franceschi, and of the Bagni di Pisa by Santi. Their activity must even be increased or modified by the presence of carbonic and sulphuric acids, of sulphur, and the earthy salts. Precise observations on their influence are therefore very desirable, and might give rise to some new views on the subject of baths, now so much investigated.

San Filippo is not only interesting in a geological and medical view; it deserves to be visited by artists on account of a manufactory of medallions in basso relievo, which is there carried on. It having been observed that bodies exposed to a current of the spring soon became encrusted with a hard and white stony layer, it occurred first to a Mr Vegni to employ this property of the spring to multiply impressions of medals, by establishing a manufactory for the purpose. In this enterprize he was encouraged by the Grand Duke Leopold, the brother, and at that period the imitator, of the immortal Emperor Joseph II. who visited the place, and gave every aid to M. Vegni. Some time after, an engraver in wood, M. Pagliari, a native of Genoa, visiting San Filippo on his return from Rome, where he had been educated, was engaged to remain there to superintend the establishment. He succeeded so well, that M. Vegni, at his death, left him his property in San Filippo. There he has continued to reside for forty years, and though now seventy-four years of age, and much deformed, he is still very active, and has contributed to benefit the village, not only by his manufactory, but by the establishment of the public mills, and the maintenance of the baths. Under the French Government this manufactory flourished: it is now in decay. I am indebted to M. Pagliari for the following details of his process, which he communicated with the greatest liberality, to which I listened with the greatest interest and pleasure, and which I saw put in execution near his habitation.

As the water of the spring contains earthy substances of different qualities, some of which do not become very compact when consolidated, the first step is to separate these by simple precipitation and crystallization. With this view, the water is conducted from its source in small superficial canals, in the course of which are three pits, between 2 and 3 feet square, placed at the distance of 5 feet from each other. During its progress, the excess of carbonic acid, combined with the earthy matter, escapes, and a portion of carbonate and large crystals of sulphate of lime are deposited in the pits. Thus freed from its grosser parts, the water is conveyed by a tube to the summit of a small chamber, from which it falls freely through a space of 10 or 12 feet upon a frame-work of wood of a pyramidal form, about 2½ feet high by 1 foot in diameter. Within the frame are disposed horizontally three series of flat cross sticks, placed about 9 inches below each other: each series is made to cross in a direction different from the one above it, and the crossed pieces increase in number and size as they descend. By this arrangement, the falling current is necessarily broken and dispersed with rapidity around the chamber. The moulds from which the casts are to be taken, are formed either of plaster of Paris, sulphur, or, what is better, of glass. If the parts of the *bas relief* to be copied are not very prominent, the mould is formed of one piece; but if there are great inequalities, it is then formed of two or more pieces. The moulds are rubbed lightly over with a solution of soap, and are attached by iron wires to narrow pieces of board, which are disposed almost perpendicularly round the frame of wood, at the distance of 2 or 3 feet. In this position they receive an equable and continued dash of water, in form of an artificial rain, during which, the deposition takes place, and the water rapidly escapes,—conditions all of which are necessary to obtain a solid and semitransparent cast like marble. A reduction of temperature in the chamber is also required to favour the deposition, but a current of cold air is not admitted, both because it would prevent the equable distribution of the water, and render the cast itself brittle. The chamber, therefore, has openings only in its upper part, to permit the rapid escape of the contained vapours. The moulds are thus left exposed to the action of the water, from ten or twelve days to two or three months, according to the size and thickness, or inequalities of the cast. A cast of 2 or 3 inches diameter, requires a thickness of at least 2 or 3 lines; one of 6 inches, 4 lines; of 1 foot, 8 lines. The casts are easily detached from the moulds, their edges clipped, and their front surface rubbed first with a subtile powder and water, and then polished with a paste composed of soap and calcined sheep bones. They acquire thus a smooth shining appearance, and their semitransparency is improved, while the back surface or *reverse* remains dull and rough.

By an ingenious variation of the process, the artist is able to form casts of differently coloured marbles, presenting thus a white figure in *relief* on a darker ground, and *vice versâ*. This is done by covering the plain parts of the mould with a thin paste, so that the deposition shall be made only into the sunk parts. When these parts are filled, the paste is detached, and the whole exposed to a water previously coloured, by dissolving a colouring substance in the last of the three pits. In this manner, while the *raised* parts have the ordinary colour, those of the *ground* exhibit that of the colouring matter employed. Metallic colours are preferred to vegetable, and oxides of iron, in particular, give their appropriate colours, without impairing the solidity of the stone.

Lastly, Impressions of engravings may be transferred to stones thus artificially prepared. The subject is first engraved on a metallic plate, and a little printer's ink passed over, so as to colour lightly the furrows. The plate is exposed to the action of the water in the manner already described, and when the cast is removed, the engraving is represented by black prominent lines, on a plain white ground. These black prominent lines are then separated by a thin and sharp knife; the cast is next warmed, and printer's ink rubbed over it, when the colouring matter is seen to adhere only to the parts that have been scratched, and the drawing on the stone corresponds exactly to the engraving on the plate. This process may perhaps furnish some hints for the improvement of artificial stone-engraving.

Notwithstanding the hardness of these casts when tried by a knife, they break without difficulty when a strong pressure is applied unequally to their surface, which may be accounted for from the fibres of the stone being short, parallel, and perpendicular to the surface, as in some species of sulphate of lime.

I subjoin a list of the prices of the casts sold by M. Pagliari at the place of manufacture:

Cast of 1 inch,	1 paolo.	Cast of 6 inches,	9 paoli.
2½	1½	7	10
4	3	9	20
5	6	1 f. 6	30

A paolo = 4d. English money.

After having thus passed some hours with M. Pagliari, and, from the hill immediately opposite to the village, taken the sketch of his habitation, as given in Plate IX., I pursued my journey, in despite of wind and rain, across the foot of the mountain. In this route, I had the misfortune to experience the fragility of the casts of San Filippo, having, by a fall, broken all the specimens I had taken away with me. I soon passed the torrent of the Rondinaya, and came again into the road of Radicofani, which begins here to ascend, and continues so for three miles. In ascending, I observed the sides of the road covered with detached angulated blocks of basaltic stone, which increased in size and number, and were intermixed with small pieces of a light hard porous lava, of a reddish-brown or blackish colour. They announced the near neighbourhood of the crater of the ancient volcano of Radicofani, known under the name of *La Badia*, and through which passed the *Via Romana*, the remains of which are still visible. The country here presents marks of dreadful devastation; the crater and its surrounding parts being filled and covered with enormous blocks, and with the lava ejected by the eruption. Radicofani is a small miserable village or *borgo* near this place, and surmounted by a ruined citadel, built on elevated basaltic rocks.

As I know that this volcanic district has lately been visited by an able mineralogist of Geneva, I hope to be able to send you a more particular account of it, if you shall deem it worthy of your attention.

EDINBURGH,
10*th February* 1820.

ART. XV.—*An Account of several Shocks of Earthquakes and other Remarkable Phenomena, which occurred in South Carolina previous to the Destruction of Laguira and Caraccas, and the Eruption of the Soufriere.* By Mr TARTT. Communicated by the Author.

THERE is not, I believe, any well attested account of an earthquake having occurred in South Carolina, from the period of its discovery to the year 1811; and as there are none of those volcanic appearances and remains in its vicinity, that usually indicate the immediate seats of such phenomena, it is reasonable to conclude, that the earthquakes of 1811 and 1812, were merely vibrations attendant upon the more alarming convulsions, by which the destruction of Laguira and Caraccas, and the eruption of the Soufriere, were produced.

The former, it will be recollected, occasioned the loss of from fifteen to twenty thousand lives; and the trembling of the earth's surface that took place in different directions about the same time, was probably more extensive than any previously upon record.

I was then in Carolina: and as it appears that the only assistance we can contribute to science, during our ignorance of the precise causes of these sublime efforts of Nature, is by correctly detailing the facts attending them, I have been induced to collect the following memoranda.

The close of the year 1811 was accompanied, in the climates I speak of, by some of the most awful phenomena to which our system is liable. We may pass over the appearance of the comet and an eclipse of the sun as merely coincident, and witnessed in common with other countries. In addition to these, the island where I then resided was completely deluged, on the 10th September, by one of those inundations of the sea that occasionally occur in tropical climates about the time of the autumnal equinox; and, excepting a space considerably less than a quarter of a mile, the waters of the Atlantic and the Mainland, materially beyond our reach, were the only objects upon which the eye could rest. This had scarcely subsided, when the city of Charleston, (whither we were about to remove), was visited by a tornado, more dreadful in its extent and effects than any in the memory of the oldest inhabitants. The wind, which had been for some days light and variable, shifted on the 8th to the north-east, and blowing very fresh through the night, it continued in the same quarter all the day and night of the 9th. During the whole of this time, there was an almost uninterrupted fall of rain; and on the morning of the 10th, the wind blew with increased violence. About 10 o'clock, it shifted to the south-east, and soon after 12 it suddenly became calm. A heavy rumbling noise, resembling the sound of a carriage rapidly driven over a pavement, was then heard; and a tornado, extending about one hundred yards in width, passed like lightning through a considerable section of the city, involving alike the habitations and the inhabitants in instant destruction. Proceeding up the harbour, the first object it struck was the flag-staff of one of the forts, of more than ordinary thickness and strength, which was snapped in a moment: and, with the same ease, houses of considerable size were not merely unroofed or injured, but completely overthrown like the playthings of an infant. Large beams of wood, and masses of lead and iron, were carried for several hundred yards, and nearly buried in the walls of other buildings: yet, so confined was its operation to a particular current of air, that corners and parts of houses were taken off, as if divided by some mechanical instrument, and the remainder of the buildings left uninjured. About twenty lives were lost; one of them under very remarkable circumstances. A lady was reposing with her sister on a bed in an upper apartment, when the tornado reached the house. The noise so alarmed a negro girl in waiting, that she sought for refuge under the bed upon which her mistress was lying. A stack of chimnies was struck with such tremendous violence, that, falling on the roof, it forced its way through the house to the ground, precipitating the floors along with it. The bed fell with them; the ladies escaped without injury; but the negro girl beneath it was crushed to pieces.

In another instance, a young female who was attending her dying mother, was carried by the hurricane from the room in which she sat, and dashed against a building at a very considerable distance.

In the interval between this calamity and the concussions of the earth, (the first of which occurred on the 16th of December), various meteors and balls of fire, of different sizes and appearances, were observed. One of them, of a magnitude calculated to excite alarm, was seen by spectators who were an hundred miles asunder, about 8 o'clock on the evening of the 21st November, moving with great rapidity in a south-west direction. It illuminated the ground and the surface of the waters, as if a torch of burning matter had been passing over them, and was conjectured, though it must have been vaguely, to have been about ten or fifteen feet in diameter. The season was unusually warm. Large apples, the produce of second crops, were seen in November; and on several plantations there were second crops of rice, which had not occurred for forty years. It may also be remarked, that there was considerably less thunder during the year 1811 than usual; the number of days, which commonly averages 60, having only amounted to 38.

On the morning of the 16th of December, about 5 minutes before 3, the first shock was felt. It awoke me from my sleep; and was said to have been preceded by the usual rattling noise. Being unapprehensive of such an event, my first impression was that the house was falling, and the cracking of its timbers strengthened me in this impression. Proceeding down stairs, however, and the noise having subsided, I began to be doubtful how far I might be under the influence of some mental delusion; and, returning to my bed, I found it still rocking from the effect of a second shock which took place about 3 o'clock. And a third and fourth, at 3 minutes before and 10 minutes past 8 o'clock, left me perfectly satisfied as to the cause of what had occurred.

From this time to the 11th of February, fourteen distinct shocks were felt, of which the most violent were the following:

On the 16th Dec. 1811,	at 2.55 A. M.	its duration 2 min.
Same day,	7.57 A. M.	30 sec.
17th Dec.	0.50 P. M.	20 sec.
23d Jan. 1812,	9.15 A. M.	1½ min.
7th Feb.	3.53 A. M.	7 min.
Same day,	10.57 P. M.	2 min.

The motion was generally from east to west, but it was not uniform. In December it appeared to be undulating; in January violent and irregular; and in February it seemed similar to a sudden jerking to and fro of the earth's surface. Between the concussions, a tremor of the earth was frequently perceptible, and light pendulous bodies were then in a state of almost constant vibration. The motion, during the severer shocks, was sufficiently violent to break the glasses of pictures hanging against the wall, and the pavements in several of the streets were cracked. Many persons also found it difficult to preserve themselves from falling.

The sky was generally, though not uniformly, dark and hazy, sometimes tinged with red, and the shocks were preceded and accompanied by severe cold, and frequent fogs, of a density unusual to the climate at the season and times when they occurred. The shock of the 7th February was attended by a noise like distant thunder; and during the night, the sea on the bar, about eight miles distant, was heard to roar unusually loud. The shock of the following evening was accompanied by a sound like the rushing of a violent wind, and with several flashes of very sharp lightning.

The thermometer at 8 o'clock on the evening of the 15th of December was 52°, and the barometer 30° 45″. The morning of the first earthquake (the 16th), the barometer continued the same, but the mercury in the thermometer had sunk to 46°. The last of these awful visitations was a slight tremor, which was felt on the day following the destruction of Laguira and Caraccas; and they passed away without a single instance of personal injury or destruction of property: but, unaccustomed as the inhabitants had been to any thing of a similar nature, their consternation and alarm were very considerable. A proclamation was issued by the governor, appointing the 11th of March as a day of humiliation, religious reflection, and prayer; and a tone of seriousness and pious feeling was for a long time perceptible, where it had previously seldom existed.

The earthquakes in Venezuela have now become matter of history, and have lately been ably detailed in the Philosophical Journal; but as the accounts of eye witnesses to such calamities are always possessed of interest, I may be allowed to conclude the present paper by the following extracts from letters written from Laguira at the time:

"On the 25th of March, at 4 o'clock P. M. there was a very severe shock of an earthquake, which destroyed nearly the whole of the city of Caraccas, and all the town of Laguira, with the neighbouring villages. About 10,000 people were buried in the ruins; 2500 in Laguira. Four shocks were heard and felt on the night following, but not heavy enough to do any damage. On the 27th ult. the people that were living were employed in digging the dead from under the ruins, putting them in lighters, carrying them outside the shipping, and burying them in the sea. On the 28th the sea was so rough as to prevent their taking them off. They then built a large fire near the wharf, and commenced burning them, and burnt about forty at a time. On the 29th the stench had become so bad, they left off digging any more dead from under the ruins, and all the surviving inhabitants pitched their tents on the plains. On the 4th of April there was a very heavy shock, that made the vessels tremble as if they had been on a reef of rocks; and from the Independence we could see the mountains move like a ship in a heavy sea, and large pieces rolling off them.

"Not a house is left standing that any one would venture to remain in for a single hour, and nine-tenths of the town are level with the ground. It is shocking to see, at the close of the day, heads, arms and legs that have remained unburnt, as the fire dies away, and the stench is intolerable; and as no day has passed without a shock, we are waiting in fear and trembling to know when it will be entirely over, or what the effect of the next will be."

This scene of misery commenced on the 25th of March; and on the 26th of the following month, the eruption of the Soufriere took place.

LIVERPOOL, *January* 31. 1820.

Art. XVI.—*Account of the Mine or Quarry of Corundum in Singraula.* By Francis Hamilton, M.D. F.R.S & F.A.S. Lond. & Edin. Communicated by the Author.

The principal Quarry of Corundum perhaps in India, is in the territory of the Singraula Raja, about eight miles south from Sahapur, where that chief usually resides, and about 120 miles from Merzapur, on the bank of the Ganges. In the rainy season of 1814, I went to the latter place in hopes of being able to visit the quarry; but several untoward circumstances prevented me, and I was under the necessity of contenting myself with such an account as I could procure from the traders, who had visited the place to purchase the commodity.

I was told by them, that the quarry is on a low ridge, covered with small fragments of the corundum, or *korund*, as it is called in the Hindwi dialect. By removing these fragments to a very little depth, larger masses are found; and such are usually selected, as are from the size of the fist to that of the head. Many larger masses are found; and when there is a deficiency of small pieces, these larger ones are split by kindling a fire on and round them. To judge from the appearances of the pieces brought to Merzapur, the large masses seem to consist of a number of smaller ones, somewhat rounded at the angles either by friction or by a partial decomposition, and afterwards conglutinated by an earthy substance containing a good deal of mica; for it would not seem that the fire rends asunder the entire stone, it seems only to separate the nodules, by rending the substance which had conglutinated them, part of which I found adhering to their surfaces.

Some of the traders asserted, that the whole ridge consists of korund; while others alleged, that the korund is only scattered on the surface or at small depths, and that the mass of the ridge consists of a stone similar to that which is used for building at Merzapur, that is, of the sandstone considered by some of the best mineralogists as nearly allied to quartz-rock, if it be at all different from this substance. All the traders agree, that the whole rocks which they have seen between Merzapur and the quarry, are of this sandstone; and it no doubt forms part of the great chain of quartz-rock, which I have mentioned in giving an account of a diamond mine in the First Number of this Journal. We may here so far trust the report of the traders as to believe, that the greater portion of the rocks by the way consists of this sandstone or quartz-rock; although it is probable, that, in such an immense mass, many beds or veins of a different nature are contained, which naturally enough escaped the notice of the traders, none of them being in demand.

Among the masses of korund brought to Merzapur, I found some pieces of white quartz brought by mistake; and many of the masses of korund, when broken, shew that in their substance are imbedded pieces of green talc and of micaceous iron-ore, besides the particles of mica that are interposed between the masses. Whether or not, however, the quantity of quartz, talc, and mica, that are intermixed, is so considerable that the masses should be considered as portions of an aggregate rock, it is impossible to say, without visiting the place, as of course the traders select the masses that are most free from intermixture. The quantity brought to Merzapur for sale is pretty considerable, as this town supplies all the provinces towards the east. The vicinity of the quarry is inhabited by persons of the rude tribe called Kol, to whom the traders carry a little salt, cloth, and various trifles, and from whom they receive chiefly iron and this korund. For the latter, they seem merely to give a small allowance to the Kol, who help them to dig and break as much as will load their oxen. The Raja seems to make no claim.

The korund from this quarry assumes a variety of appearances; but, although I looked over great quantities, I perceived no crystals, nor did the traders recollect having seen any in that form. The generic marks of corundum seem to be great hardness and great specific gravity. The native artificers distinguish that of this quarry into different kinds, as suited for different purposes: some serves to clean small arms, some to grind cutting instruments, and some to polish stones; but I did not learn the marks by which the artificers distinguish the different kinds; although, it is said, that they can distinguish them at sight. Some of the specimens which I brought from thence, by my mineralogical acquaintances at Edinburgh were called Corundum, others Emery, and others Fibrolite; while others alleged, that all these names belong in fact to one substance:

nor is there any reason to suppose, that the three kinds thus distinguished by some of the mineralogists, correspond at all with the three kinds acknowledged by the Indian artificers. I have, however, little doubt, that a proper examination of numerous specimens would enable a judicious mineralogist to divide corundum into several species, possessed of peculiar qualities to suit each for some useful purpose, and not founded on hypothetical conjectures respecting their formation, or trifling variations of appearance, which are only worthy of notice, so far as they may enable us to distinguish the substance from others of a different nature, and the various useful species from each other.

ART. XVII.—*Account of Rocks formed by Hot-Springs, Torrents of Hot Water, bursting of Subterranean Lakes, Air-Volcanoes, and Cold-Springs.* By Professor JAMESON [*].

1. *Rocks formed from the Water of Hot-Springs.*

MANY of the more observing and intelligent of the inhabitants of Iceland believe, that certain rocks in their country have been formed by deposition from the water of hot-springs. This opinion, which at first sight appears very improbable, was adopted by the travellers Olafsen and Povelsen, who were several years occupied in examining the natural history of that remarkable island, and who describe whole mountains as having been formed by hot-springs. And, very lately, M. Menge, as stated in the last Number of our Journal, returned from Iceland fully convinced, that very extensive formations of *thermal rocks* extend throughout that extraordinary country. As we consider this fact one of great geological importance, we shall now lay before our readers some account of the observations of Olafsen and Povelsen and Menge, and accompany it with occasional remarks.

In the Borgarfiord district, in southern Iceland, there is a striking and lofty mountain named Baula, of a white colour, and of a rather irregular structure. Nearly the whole mass, from its base to its summit, as determined by numerous natural perpendicular sections, is composed of a rock described by Olafsen and Povelsen under the title, "*Saxum tophaceum albidum columnare sive basaltiforme*," and which they say is named by the Icelanders Baula-stone, because it occurs only or principally in this mountain. It is either massive, or disposed in columns, having three, four, five, six, seven, eight or nine sides, and of a middling degree of hardness. Externally it is pale red; internally it is whitish, and feels dry and sharp, and is lighter than true basalt. It does not effervesce with acids. They further remark, that it resembles other columnar rocks in form, but differs from them in colour, feel and weight; but agrees in so many characters with deposites found around hot-springs, that they consider the whole mountain as a *thermal formation*, which was at first soft, and in the state of bole, but was afterwards hardened by the influence of internal heat. These travellers found a rock of the same description on the summits of the highest mountains in Iceland, principally in the Westfiorden. A second thermal rock is described under the title, "*Saxum concretum tophaceum stratosum, colore pallido*," and which is named by the Icelanders Hverhella. It is generally of a white colour, is more or less vesicular, sometimes inclines to vitreous, and possesses considerable hardness. It often occurs in large beds, which are either horizontal or irregularly disposed, where hot-springs are in a state of activity, or in places where hot-springs formerly existed, but have long since ceased to play. Connected with both these rocks, there is a vitreous or glassy looking substance, of the nature of obsidian, but very different from the volcanic mineral of that name,—the one being a product of hot-springs, while the other is perfectly melted volcanic glass. A third thermal rock is particularly noticed by Olafsen and Povelsen, under the name "*Saxum tophaceum brunneo-pallidum lithoxylis phytolithisque repletum.*" It is of a brown colour, vesicular, but not to the same degree as the preceding kind. It contains portions of vegetables more or less completely silicified. It is found in the vicinity of hot-springs, and in many districts where hot-springs were formerly in activity. A fourth thermal rock is named "*Saxum tophaceum similiquatum nigricans thermarum.*" This curious rock is of a black colour, and in hand specimens very much resembles earthy slag. It is formed by the hot-springs of Leyraa, and also by the waters of many other hot-springs in Iceland.

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[*] Read before the Wernerian Natural History Society, 12th February 1820.

Besides these mineral productions of hot-springs, the Danish naturalists enumerate the following, which are of a looser texture:

1. *Bolus violacea.* This violet-coloured bole or clay effervesces with acids, and is found in great quantity around active hot-springs, and in extensive districts where such springs formerly existed.

2. *Bolus thermarum cærulea.* This blue bole contains imbedded crystals and grains of iron-pyrites, occasionally sulphur, and has a sourish taste. Some of the eminences formed of it are still hot, so that if we dig three or four feet deep into the bole, the heat is so great that we cannot hold our hand in it. Whole hills are formed of this bole, which, in such cases, is frequently disposed in strata.

3. *Bolus brunnea. Tripoli of Iceland.* This rock is hard, and sharp to the feel, and has many of the characters of Tripoli. It appears to be a thermal bole or clay, impregnated with silica. The water of hot springs flowing over such a rock, might give rise to veins and masses of pearl-sinter, hyalite, opal and obsidian.

Such are the observations of Olafsen and Povelsen, which appear to shew the formation of columnar and massive rocks by hot-springs, and also of obsidian, hyalite, pearl-sinter and opal.

Dr Henderson, in his Travels in Iceland, alludes to the formation of rocks by hot-springs; but Sir G. Mackenzie, in his work, does not refer any of the rocks he met with in Southern Iceland to the thermal class. Menge, an active naturalist, was aware of the interesting and important nature of these thermal formations. He observed thermal rocks having many of the characters of basalt, porphyry, wacke, amygdaloid, tuffa and obsidian. These he met with in districts where formerly hot-springs occurred; and observed them still forming around many of the magnificent hot-springs at present in a state of activity. These thermal trap-rocks, viz. basalt, wacke, amygdaloid with calcareous-spar, porphyry, &c. are brought from the interior of the earth, by the water of hot-springs, partly in a state of solution, partly in a state of mud, and are deposited over flat or hilly tracts of country, when they gradually harden, sometimes crystallise, and assume their various permanent characters. The amygdaloidal traps appear to be formed in those cases where carbonate of lime is present; the obsidian where dissolved silica prevails; and in the same general way we might account for the formation of the other rocks. In the collection of Islandic Minerals presented to the Museum of our University by Sir George Mackenzie, there are specimens of a few of these thermal rocks; but the series not being complete, we cannot from it draw up an accurate statement of the characters which they exhibit in hand specimens, far less point out in a satisfactory manner, those general features that characterise them as a member in the grand series of mountain rocks. Menge has promised to transmit a set of these remarkable rocks, which will afford us an opportunity, in some future number of our Journal, to make our readers more particularly acquainted with them.

In other parts of the world, where hot-springs have flowed, or still continue in activity, similar formations, we have no doubt, will be met with. The breccias and tuffas in the trachyte district in Hungary, and which contain opal and opalised wood, appear to be formations of hot-springs. Probably even some of the trachytes have been formed in a similar way. The same remark applies to some rocks found in Auvergne. But besides these trap and porphyry rocks, hot-springs also throw out and form rocks of a calcareous nature. The hot-springs of Carlsbad in Bohemia are of this description, and the well known hot-springs of San Filippo in Tuscany, have formed a hill of calcareous tuffa, in many places as compact and hard as limestone *. The famous rock named *travertino* by the Italians, and which abounds in South-western Italy, is a product partly of hot, partly of cold springs. The ancient temples, and the gorgeous palaces and churches of Rome, and indeed the whole of the streets and squares of the former Mistress of the World, are built of concretionary masses which have been deposited by springs.

There are many considerable hot-springs around Guancavelica in South America, the waters of which spread over the neighbouring country, and deposit upon it an ash-grey or whitish substance, (calc-tuff, sinter and travertine ?), which acquires a great degree of hardness. The spring-water is so highly impregnated with the earthy matter, that the inhabitants receive it in square boxes or moulds, which it fills in a few days, and the blocks, thus formed, are used for building. Indeed the greater part of Guancavelica, like Rome, is built of the concretionary rock formed from springs *.

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* In our present number, we have inserted an interesting account of the spring of St Filippo, by our acute and learned friend Dr Gosse of Geneva.

2. *Rocks formed from torrents of Hot-Water issuing from Volcanoes.*

There are on record authentic instances of torrents of hot water flowing from the crater or the sides of volcanoes, when in a state of activity, which, when collected in hollows, or spread over plains, deposites various earthy matters, which at length assume the character of rocks. In the year 1751, a torrent of salt water burst from Ætna, and continued to flow for a quarter of an hour, and was so considerable that the inhabitants named it *Nilo d'Acqua.* Dolomieu and Hamilton observed traces of a frightful torrent of hot water which had issued from the great crater of Ætna; and Spallanzani is of opinion, that part of the tuffas of Italy have been formed by muddy eruptions. In those volcanic mountains whose summits are above the snow line, as is the case in Iceland and in South America, great floods of hot water, charged with earthy matter, burst from the mountains and devastate the surrounding country. Bouguer and Condamine saw dreadful ravages committed by these torrents; and the latter writer informs us, that after an explosion of Cotopaxi, a village situated thirty leagues in a straight line, and probably sixty leagues following the wavings of the ground, was entirely carried away by one of those torrents. These torrents from the ice-caped volcanoes, appear to be entirely external, while those first mentioned seem to come from the interior of the volcanoes.

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* Masses of siliceous matter, probably the formation of hot-springs, have been found, inclosing foreign bodies of different kinds. Of this description are the masses of siliceous matter inclosing coins, described by authors, and which have been held as fabulous. The following is an instance of this fact. In the year 1812, a mass of flinty matter, twelve inches long, was dug up in France, in the interior of which there were several coins, the most ancient of which were of the sixteenth century. (*Journal des Mines*, p. 23.) Vegetables are also occasionally found included in a siliceous basis of an opaline or chalcedonic nature, and of these Daubenton and others have given particular descriptions.

3. *Rocks formed by Torrents of Mud flowing from Subterranean Lakes.*

In the interior of volcanic mountains, there sometimes occur caverns or hollows partly filled with water, thus forming subterranean lakes. The earthquakes that often agitate these mountains, are occasionally so violent, as to produce great rents, which give free passage to the water of the lakes, which bursts forth with tremendous violence, deluges the neighbouring country, and covers it to a greater or less extent, and with a more or less deep crust of muddy matter. In the earthquake of the year 1746, which overturned Lima, four volcanoes opened at Lucanas and in the mountains of Conception, and occasioned frightful deluges. The volcanoes of the kingdom of Quito sometimes exhibit phenomena of the same kind, but accompanied with circumstances so extraordinary, that we shall now state them. The enormous volcanic cones of Cotopaxi, Pichincha, Tungouragua, &c. in South America, never throw out lava, but frequently ashes, scoriæ, and pumice, and sometimes vomit forth immense quantities of water and mud. These eruptions take place more frequently from the sides than from the craters of the volcanoes, and the muddy waters appear to be derived from lakes situated in the interior of the mountains, which burst forth with incredible fury, when any accidental cause, such as an earthquake, splits, and thus opens the side of the mountain. In the year 1698, the mountain of Carguarazo, near to Chimboraco, fell down and covered eight square leagues of country with mud. In the earthquake of the 4th February 1791, 40,000 persons were destroyed by eruptions of water and mud, (moya). Muddy waters, resembling those which flow from volcanic mountains, are vomited forth in great quantity, from districts where no volcanic rocks occur, when these are agitated by earthquakes or other causes. In Peru and Quito, the devastations occasioned by volcanoes are not caused *by streams of lava*, but by water and *enormous streams of mud.* This substance, which at first has only the consistence of *bouilli*, but soon hardens on exposure, is named *Moya.* It presents two remarkable phenomena, viz. an intermixture of inflammable matter and of fishes. The inflammable matter is so abundant that the inhabitants of the districts use it in place of *fuel.* The moya which was thrown out after the terrible earthquake of 1797, and which inundated the country of Pelileo, and destroyed the village of that name, was remarkable for its abundance of inflammable matter. Very often these streams of mud from the interior of the mountains, bring along with them fishes about four inches in length, named by Humboldt *Pimolides Cyclopum,* and the quantity is sometimes so considerable, that their putrefaction occasions diseases in the country. Humboldt remarks, that they are of the same species as occur in the rivulets of the neighbouring country, and appear to find their way into the subterranean lakes by means of fissures in the rocks. This mud or moya, so remarkably distinguished by its inflammable ingredient and imbedded fishes, is further interesting, by its containing traces of glassy felspar, and imbedded portions of a fibrous substance somewhat resembling pumice. It is probable that it is an altered porphyry; and we are of opinion, that when completely indurated, it will exhibit characters of the same general nature with those observed in some porphyries, said to be of volcanic and igneous origin.

4. *Rocks formed by Air or Mud Volcanoes.*

In some countries, jets or great bubbles of water, highly impregnated with mineral matter, are thrown out of the earth by means of gas. The earthy matter is deposited in the state of mud, principally around the mouths of the cones from whence it is expelled; and as these cones somewhat resemble volcanoes in form, they have been named *Air-volcanoes.* One of the most remarkable of these air-volcanoes hitherto described, is that of Macalouba in Sicily, of which an account has been published by Dolomieu. It consists of a hillock of hardened mud, about one hundred and fifty feet in height. Its superior part forms a plain more than half a mile in circumference, and rising from it are numerous small cones not more than three feet in height, each of which has a crater or hollow filled more or less deeply with a liquid mud, which is in a state of perpetual agitation, owing to the constant passage of great bubbles of air through it. Portions of the mud are constantly thrown out, and thus add to the bulk and height of the cones.

This air-volcano is usually in the state we have just described it, but not always, for it is occasionally very much agitated, and exhibits phenomena of a more striking and extensive nature. When this is the case, loud internal noises are heard, and these are accompanied with sharp shocks of earthquakes, which are felt to a distance of two or three miles, and these noises and earthquakes continue more or less for several days, and do not cease until an eruption takes place of an enormous jet of clay, earth, and stones, which are thrown into the air the height of two or three hundred feet. The explosions are repeated two or three times in the space of twenty-four hours. There are years when no eruption takes place. The following is an account of one of these eruptions as given by an eye-witness. A dull noise was heard; the earth in the neighbourhood was much agitated, and large rents opened. There arose from the centre of the plain, a bubble of diluted clay, sixty feet in diameter, which gradually increased in magnitude, and attained the enormous elevation of two hundred and thirty feet. This extraordinary and striking spectacle continued for half an hour; was repeated three times, with an interval between each of a quarter of an hour; and, during its continuance, a stormy noise, like that of the sea agitated by a tempest, was heard to proceed from below. The author of this account seized the first moment to approach the point from whence the explosion proceeded; he plunged his arm into a place where the ebullition was still visible, but did not feel any increase of temperature; on the contrary, the mud felt cold.

There are many small *mud-volcanoes* in the neighbourhood of Modena, whose height is not more than a few feet. They are named *Salses*, on account of the saltness of the water they throw out; and which, indeed, is also the case with the water of Macalouba, and of that of most other muddy eruptions observed in different countries. These volcanoes, during their paroxysms, which are attended with slight agitations of the earth, throw out much mud, which extends to the distance of three thousand feet. The gas which occasions the eruptions, is sulphuretted hydrogen mixed with petroleum, and a little carbonic acid. Similar air-volcanoes are described by Pallas as occurring in the Crimea, particularly in the Island of Taman. In the year 1794, one of these burst with a noise like that of thunder, and flame and smoke rushed from it to the height of more than three hundred feet. Great masses of dried mud were projected from it to great distances, and it vomited forth currents of *a bituminous mud or slime*, to the amount of one hundred thousand cubic fathoms. Humboldt describes air-volcanoes which he saw in the middle of an elevated plain, in the province of Carthagena in South America. There were twenty small cones, having an elevation of from twenty-one to twenty-seven feet in height, and formed of bluish coloured clay. Their summits were hollow or crater-like, filled with water, from the surface of which air arose, and burst with an explosion, and often threw out mud. In the Island of Trinidad *, and also in Java, there are considerable air or mud volcanoes.

5. *Rocks formed from Cold-Springs.*

Many cold or common perennial springs throw out great quantities of earthy matter, principally calcareous, and thus give rise to extensive depositions of calcareous tuffa and sinter. Independent of the thick incrustation formed on the surfaces of craggs and cliffs, and rents of rocks, by the water of such springs, and of which we have a fine example at Starlyburn in Fifeshire, we find that when the water flows into hollows and forms lakes, that then very thick and extensive calcareous formations take place. Thus in Thuringia there are very extensive lake-deposites of calcareous tuffa and sinter. In some districts in that part of Germany, the tuffa rests upon gravel, or on some of the solid strata of the country, and forms beds sometimes fifty feet thick, and which are composed of alternate strata of compact and friable tuffa, with occasional thin beds of bituminous matter. It is in this calcareous formation, that the remains of fossil elephants, rhinoceri, &c. are found in different parts of Germany. It is an important fact, as connected with these fossil animal remains, that the tuffa in which they are envelloped, contains fresh-water shells, analogous to those at present met with in the country where the tuff occurs, but no sea-shells, which proves that these elephants, rhinoceri, &c. could not have been brought from a distance, but must have lived and died in the spot where they are at present found.

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* An account of the mud volcanoes in Trinidad, by Dr Ferguson, will be found in the *Edin. Trans.* Vol. IX., p. 93., now in the press.

Some of the newer secondary rocks may have been formed from the water of cold-springs alone, collected into hollows, and thus forming lakes; or from hot-springs in the same circumstances; or from both conjoined. The newer secondary, more properly tertiary, formations of limestone, marl, opal, quartz, &c. may have been formed in this way.

General Results.

From the preceding rapid sketch it appears,

1. That the water of springs and of volcanoes forms rocks of various descriptions, some of which nearly resemble those of the volcanic class, while others have a strong resemblance to the formations of the secondary class.

2. That as these springs and volcanoes are very generally distributed over the earth, it follows that the rocks above described, may occur in very considerable abundance, and form striking and extensive features in the physiognomy of some tracts of country.

3. That many of these rocks, from their close resemblance to volcanic productions, may have been confounded with them.

4. That the following rocks and simple minerals have been, and are still forming by the agency of springs, and the water of volcanoes:

1. *Rocks resembling Trap and Volcanic Rocks.*—Basalt, Wacke, Amygdaloid, Tuffa, Porphyry, Greenstone, Obsidian, and various clays and boles.
2. *Rocks resembling Flœtz or Secondary Rocks.*—Travertino, Calcareous-tuffa, Calcareous-sinter, and Marl.
3. *Simple Minerals.*—Pearl-sinter, and probably also Precious Opal, Common Opal, and Jaspers of various descriptions.

Art. XVIII.—*Description and Use of a Table for Correcting the observed Altitude of the Sun's Lower Limb.* By Mr W. Galbraith. In a Letter to Dr Brewster.

Having seen a very neat and commodious Table of Proportional Logarithms in the last Number of the Edinburgh Philosophical Journal, I conjectured that you meant to convey to the public, through that medium, useful tables, when they fall in your way. In consequence of this, I have been tempted to offer you the following small table, intended to facilitate the method of correcting the observed altitude of the sun's lower limb by the fore observation at sea. It contains the joint effect of the sun's semi-diameter, dip of the horizon, refraction, and parallax, and is always to be *added* to the observed altitude, to find the true. In the computation of the table, the sun's semidiameter is taken at 16′; and its variation from this quantity, for each month in the year, is given at the bottom of the table, which must be added to, or subtracted from, the correction found in the table, which may be done at sight, according as the sign is + or —. It may be remarked, too, that the table does not extend to altitudes lower than 5°, the lowest altitude at which observations can be taken to be depended on for their accuracy. This renders all the numbers *additive*, except the small table of corrections for the variation of the sun's semi-diameter, which may, in most cases, unless a dip-sector is used, be neglected; since, according to the accurate observations with this instrument by the ingenious Captain Basil Hall, much greater errors, arising from the variable state of the horizontal refraction, when this instrument is not used, are unavoidable.

EXAMPLE.

The observed altitude of the sun's lower limb by the fore observation, is 48° 46′, and height of the eye 20 feet, in the month of November; required the true altitude of the sun's centre?

1. By this Table.		2. By the usual Tables.	
Sun's obs. alt. lower limb,	48° 46′	- -	48° 46′ 0
Correction to 49°, 20 feet,		Semi-diameter,	+ 16 12
and November,	+ 11	Dip, -	— 4 26
		Refraction,	— 50
True alt.	48 57	Parallax,	+ 6
		True alt. as before,	48 57 2

Hence the simplicity of our method is evident, while it obviously possesses all the requisite accuracy, since it never can deviate more than one or two tenths of a minute from the truth, and is therefore fully sufficient for all purposes at sea.

EDINBURGH, *Feb.* 1820.

Obs. Alt.	Height of the Eye above the Sea in Feet.															
	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
5° 0′	3′.8	3′.5	3′.1	2′.8	2′.5	2′.3	2′.1	1′.8	1′.6	1′.4	1′.2	1′.0	0′.8	0′.6	0′.5	0′.3
5 20	4.3	4.0	3.6	3.3	3.1	2.8	2.6	2.3	2.1	1.9	1.7	1.5	1.3	1.1	1.0	0,8
5 40	4.8	4.5	4.1	3.8	3.5	3.3	3.1	2.8	2.6	2.4	2.2	2.0	1.8	1.6	1.5	1.3
6 0	5.3	4.9	4.6	4.3	4.0	3.7	3.5	3.3	3.0	2.8	2.6	2.4	2.2	2.1	1.9	1.7
6 20	5.7	5.4	5.0	4.7	4.4	4.1	3.9	3.7	3.3	3.2	3.0	2.8	2.6	2.5	2.3	2.0
6 40	6.0	5.7	5.3	5.0	4.7	4.5	4.3	4.0	3.8	3.6	3.4	3.2	3.0	2.8	2.7	2.3
7 0	6.4	6.0	5.7	5.4	5.1	4.8	4.6	4.4	4.1	3.9	3.7	3.5	3.3	3.2	3.0	2.7
7 20	6.7	6.3	6.0	5,7	5.4	5.1	4.9	4.7	4.4	4.2	4.0	3.8	3.6	3.5	3.3	3.1
7 40	6.9	6.6	6.2	5,9	5.7	5.4	5.2	4.9	4.7	4.5	4.3	4.1	3.9	3.8	3.6	3.4
8 0	7.2	6.8	6,5	6.2	5.9	5.7	5.4	5.3	5.0	4.8	4.6	4.4	4.2	4.0	3.9	3.7
8 20	7 5	7.1	6.7	6.5	6.2	5.9	5.7	5 5	5.2	5.0	4.8	4.6	4,4	4.3	4,1	3.9
8 40	7.7	7.3	7.0	6.7	6.4	6.1	5.9	5.7	5.5	5.2	5.0	4.8	4.7	4.5	4.3	4.1
9 0	7.9	7.5	7.2	6.9	6.6	6.4	6.1	5.9	5.7	5.5	5.3	5.1	4.9	4.7	4.5	4.4
9 20	8.1	7.7	7.4	7.1	6.8	6.6	6.3	6.1	5.9	5.7	5.5	5.3	5.1	4.9	4.7	4.6
9 40	8.3	7.9	7.6	7.3	7.0	6.7	6.5	6.3	6.1	5.8	5.6	5.4	5,3	5.1	4.9	4.7
10 0	8.5	8.1	7.8	7.5	7.2	6.9	6.7	6.5	6.2	6.0	5.8	5.6	5.4	5.3	5.1	4.9
10 30	8.7	8.3	8.0	7.7	7.4	7.2	6.9	6.7	6,5	6.3	6.1	5.9	5.7	5.5	5.4	5.2
11 0	8.9	8.6	8.2	7.9	7.6	7.4	7.2	6.9	6.7	6.5	6.3	6.1	5.9	5.7	5.6	5.4
11 30	9 1	8.8	8.4	8.1	7.8	7.6	7.4	7.1	6.9	6.7	6.5	6.3	6.1	5.9	5.8	5.6
12 0	9.3	9.0	8.6	8.3	8.0	7.8	7.6	7.3	7.1	6.9	6.7	6.5	6.3	6.2	6.0	5.8
13	9.6	9.3	9.0	8.7	8.4	8.1	7.9	7.7	7.4	7.2	7.0	6.8	6.6	6.5	6.3	6.1
14	9.9	9.6	9.2	8.9	8.7	8.4	8.2	7.9	7.7	7.5	7.3	7.1	6.9	6.8	6,6	6.4
15	10.2	9.8	9.5	9.2	8.9	8.7	8.4	8.2	8.0	7.8	7.6	7.4	7.2	7.0	6.9	6.7
16	10.4	10.1	9.7	9.4	9.1	8.9	8.7	8.4	8.2	8.0	7.8	7.6	7.4	7.2	7.1	6.9
17	10.6	10.3	9.9	9.6	9.3	9.1	8.9	8.6	8.3	8.2	8.0	7.8	7.6	7.4	7.3	7.1
18	10.8	10.4	10.1	9.8	9.5	9.3	9.0	8.8	8.6	8.4	8.2	8.0	7.8	7.6	7.5	7.3
19	11,0	10.6	10,3	10.0	9.7	9.4	9.2	9.0	8.8	8.5	8.3	8.1	8.0	7.8	7 6	7.4
20	11.1	10.7	10.4	10.1	9.8	9.6	9.3	9.1	8.9	8.7	8.5	8.2	8.1	7.9	7.7	7.6
21	11.2	10.9	10.5	10.2	10.0	9.7	9.5	9.2	9.0	8.8	8.6	8.4	8.2	8.1	7.9	7.7
22	11.4	11.0	10.7	10.4	10.1	9.8	9.6	9.4	9.1	8.9	8.7	8.5	8.3	8.2	8.0	7.8
23	11.5	11.1	10.8	10.5	10.2	9.9	9.7	9.5	9.2	9.0	8,8	8.6	8.4	8.3	8.1	7.9
24	11.6	11.2	10.9	10.6	10.3	10.0	9.8	9.6	9.3	9.1	8.9	8.7	8.5	8.4	8.2	8.0
25	11.7	11.3	11.0	10.7	10.4	10.1	9.9	9.7	9.4	9.2	9.0	8.8	8.6	8.5	8.3	8.1
26	11.7	11.4	11.0	10.7	10.5	10.2	10.0	9.7	9.5	9.3	9.1	8.9	8.7	8.6	8.4	8.2
27	11.8	11.5	11.1	10.8	10.5	10.3	10.1	9.8	9.6	9.4	9.2	9.0	8.8	8.6	8.5	8.3
28	11.9	11.6	11.2	10.9	10.6	10.4	10.2	9.9	9.7	9.5	9.3	9.1	8.9	8.7	8.5	8.4
30	12.0	11.7	11.3	11.0	10.8	10.5	10.3	10.0	9.8	9.6	9.4	9.2	9.0	8.9	8.7	8.5
32	12.2	11.8	11.5	11.2	10.9	10.6	10.4	10.2	9.9	9.7	9.5	9.3	9.1	9.0	8.8	8.6
34	12.3	11.9	11.6	11.3	11.0	10.7	10.5	10.3	10.1	9.9	9.6	9.4	9.2	9.1	8.9	8.7
36	12.4	12.0	11.7	11,4	11.1	10.8	10.6	10.4	10.2	9.9	9.7	9.5	9.3	9.2	9.0	8.8
38	12.5	12.1	11.8	11.5	11.2	10.9	10.7	10.5	10.2	10.0	9.8	9.6	9.4	9.3	9.1	8.9
40	12.5	12.2	11.8	11.5	11.3	11.0	10.8	10.5	10.3	10.1	9.9	9.7	9.5	9.4	9.2	9.0
42	12.6	12.2	11.9	11.6	11.3	11.1	10.8	10.6	10.4	10.2	10.0	9.8	9.6	9.4	9.3	9.1
44	12,7	12.3	12.0	11.7	11.4	11.1	10.9	10.7	10.5	10.2	10.1	9.8	9.7	9.5	9.3	9.1
46	12.7	12.4	12.0	11.7	11.5	11.2	11.0	10.7	10.5	10.3	10.2	9.9	9.7	9.6	9.4	9.2
48	12.8	12.4	12.1	11.8	11.5	11.3	11.0	10.8	10.6	10.4	10.2	10.0	9.8	9.6	9.5	9.3
50	12.8	12,5	12.2	11.9	11.6	11.3	11.1	10.9	10.6	10.4	10.3	10.0	9.8	9.7	9.5	9.3
52	12.9	12.5	12.2	11.9	11.6	11.4	11.1	10.9	10.7	10.5	10.3	10.1	9.9	9.7	9.6	9.4
54	13.0	12.6	12.3	12.0	11.7	11.4	11.2	11.0	10.7	10.5	10.3	10.1	9.9	9.8	9.6	9.4
56	13.0	12.6	12.3	12.0	11.7	11.5	11.2	11.0	10.8	10.6	10.4	10,2	10.0	9.8	9.7	9.5
58	13.0	12.7	12.3	12.0	11.7	11.5	11.3	11.0	10.8	10.6	10.4	10.2	10.0	9.9	9.7	9,5
60	13.1	12.7	12.4	12.1	11.8	11.6	11.3	11.1	10.9	10.6	10.4	10.2	10.1	9.9	9.7	9.5
62	13.1	12.8	12.4	12.1	11.8	11.6	11.4	11.1	10.9	10.7	10.5	10.3	10.1	9.9	9.8	9.6
64	13.2	12.8	12.5	12.2	11.9	11.6	11.4	11 2	10.9	10.7	10.5	10.3	10.1	10.0	9.8	9.6
66	13.2	12.8	12.5	12.2	11.9	11.7	11.4	11.2	11.0	10.8	10.6	10.4	10.2	10.0	9.8	9,7
70	13.3	12,9	12.6	12.3	12.0	11.8	11.5	11.3	11.0	10.8	10.6	10.4	10.2	10.1	9.9	9.7
80	13.4	13.1	12.7	12.4	12.1	11.9	11.7	11.4	11.2	11.0	10.8	10.6	10.4	10.2	10.1	9.9
90	13.6	13.2	12.9	12,6	12.3	12.0	11.8	11.6	11.3	11.1	10.9	10.7	10.5	10.4	10.2	10.0

Month,	Jan.	Feb.	Mar.	April,	May,	June,	July,	Aug.	Sept,	Oct.	Nov.	Dec.
Correction,	+0′.3	+0′.2	+0′.1	0′.0	—0′.2	—0′.2	—0′.2	—0 ·2	—0′.1	+0.′1	+0′.2	+0′.3

ART. XIX.—*Results of Captain* KATER'S *Experiments for determining the Length of the Pendulum, at the principal Stations of the Trigonometrical Survey.*

OUR readers are no doubt well acquainted with the beautiful method of measuring the length of the pendulum which was invented by Captain Henry Kater, and which he so successfully employed in determining the length of the seconds' pendulum in the latitude of London. The superiority of this method, and the consistency of the results which it yielded, pointed out Captain Kater as the fittest person to extend the experiments to different points of the meridian; and in pursuance of the resolution of the House of Commons of the 15th March 1816, the Royal Society of London requested this active astronomer to ascertain the length of the seconds' pendulum at Unst, Portsoy, Leith Fort, Clifton, Arbury Hill, and Shanklin Farm, the principal stations of the Trigonometrical Survey. Arduous as this undertaking was, Captain Kater did not hesitate to quit his family and his scientific pursuits, and devote himself, with his usual ardour, to an enquiry in which the scientific character of his country was so much concerned. The wise liberality of the British Government furnished him with all the requisite instruments, and every facility which such an undertaking required; and he left London on the 24th June 1818, accompanied with Lieutenant Franks, with the view of beginning his operations at Unst in Orkney, the most northerly station of the survey. He arrived at Leith on the 28th June, and reached Unst on the 9th July, in the Nimrod, commanded by Captain Dalling. After finishing his observations in the Orkneys, he arrived at Portsoy on the 1st August; at Edinburgh on the 28th of August; at Clifton on the 28th September; at Arbury Hill on the 15th October; and at Shanklin Farm, in the Isle of Wight, about the 10th of May 1819, where he completed the series of laborious operations which he had undertaken. The following are the results of these operations, as given by Captain Kater himself in the Philosophical Transactions for 1819, Part III.

Results of the Operations.

" It now remains to give in one view, the results of the operations that have been detailed. These are comprised in the following table. It would have been desirable to have expressed the length of the pendulum vibrating seconds, in parts of the scale which forms the basis of the Trigonometrical Survey of Great Britain, the Commissioners of Weights and Measures having agreed to recommend that the " standard used in the Trigonometrical Survey of Great Britain should be considered as affording the most authentic determination of the linear measure of the United Kingdom." But as experiments are yet wanting to enable me to do this with sufficient accuracy, I have given the length of the pendulum in parts of Sir George Shuckburgh's standard scale, the correction for the difference between which, and the national standard of linear measure, may be readily applied hereafter.

The length of the pendulum vibrating seconds in the latitude of London, is stated in the *Phil. Trans.* for 1818, to be 39,13860 inches. But I have here to notice a very important omission, which I am obliged to Mr Troughton for having pointed out in the first number of the *Edinburgh Philosophical Journal.* It may be seen, that in computing the specific gravity of the pendulum, I have neglected to include the deal ends. Anxious to supply this omission in the most unexceptionable manner, I thought it best to take the specific gravity of the whole pendulum, and for this purpose requested Mr Barton, Comptroller of his Majesty's Mint, to allow me the use of the fine balance lately constructed under his directions, a request with which he most obligingly complied, and favoured me with his assistance, and with every requisite for making the experiment.

A deal trough was prepared, seven feet long, nine inches wide, and the same depth. The pendulum was slung horizontally from the scale pan, by a fine iron wire. The weight of the whole was carefully determined in air, and found to be 66904 grains. The trough which had been previously placed beneath the pendulum, was then filled with distilled water, and the weight of water displaced was found to be 9066 grains. The small portion of iron wire which was immersed in the water was carefully noted; the weight of the wire by which the pendulum was suspended, was 56 grains, and the weight of water equal in bulk to that part of the wire which was immersed was 2,5 grains. The temperatuure of the water was 68°, and that of the atmosphere 62°; the barometer 29,9 inches. Hence we have the weight of the pendulum 66858,8 grains in vacuo, at the temperature of 62°; the weight of an equal bulk of water at the same temperature, 9068,4 grains; and the resulting specific gravity of the pendulum, 7,3727.

Employing this specific gravity in computing the allowance for the mean buoyancy of the atmosphere, we obtain ,00624 for this correction instead of ,00545, the former erroneous conclusion. Besides this, the allowance + ,00031 for the height of the pendulum above the level of the sea, should, according to Dr Young's investigation, have been multiplied by $\frac{66}{100}$, making + ,00021 of an inch. These corrections being applied, we have 39,13929 inches of Sir G. Shuckburgh's standard scale, for the length of the pendulum vibrating seconds in the latitude of London.

Wishing to compare with this, the result which would have been obtained by means of the weights and specific gravities of the different parts of the pendulum, I carefully measured the deal ends, and found them to contain 3,956 cubic inches. The weight of the knife edges was 370 grains, and their specific gravity 7,84.

With these data, and taking the specific gravity of deal at 0,49; the specific gravity of the whole pendulum will be found to vary from the more accurate determination above given, a quantity which would have occasioned a difference in the length of the seconds pendulum of only $\frac{1}{50000}$ of an inch.

Place of Observation.	Latitude.	Vibrations in a mean solar day.	Length of the Pendulum vibrating seconds in parts of Sir George Shuckburgh's scale.
	° ′ ″		Inches.
Unst, - -	60.45.28,01	86096,90	39,17146
Portsoy, - -	57.40.58,65	86086,05	39,16159
Leith Fort, -	55.58.40,80	86079,40	39,15554
Clifton, - -	53.27.43,12	86068,90	39,14600
Arbury Hill, -	52.12.55,32	86065,05	39,14250
London, - -	51.31. 8,40	86061,52	39,13929
Shanklin Farm,	50.37.23,94	86058,07	39,13614

By comparing the observations of each station successively with those at all the others, Captain Kater obtained the results in the following Table, containing the diminution of gravity, and the resulting compression deduced, in a way which is fully explained in the paper itself.—See *Phil. Trans.* 1819., p. 420.

Names of the Stations.	Diminution of gravity from the Pole to the Equator.	Compression.
Unst and Portsoy,	,0053639	$\frac{1}{304,3}$
Leith Fort,	,0054840	$\frac{1}{315,8}$
Clifton,	,0056340	$\frac{1}{331,5}$
Arbury Hill,	,0054282	$\frac{1}{310,3}$
London,	,0055510	$\frac{1}{322,7}$
Dunnose,	,0055262	$\frac{1}{320,1}$
Portsoy and Leith Fort,	,0056920	$\frac{1}{338,0}$
Clifton,	,0058194	$\frac{1}{353,2}$
Arbury Hill,	,0054620	$\frac{1}{313,7}$
London,	,0056382	$\frac{1}{332,0}$
Dunnose,	,0055920	$\frac{1}{326,9}$
Leith Fort and Clifton,	,0059033	$\frac{1}{364,0}$
Arbury Hill,	,0053615	$\frac{1}{304,1}$
London,	,0056186	$\frac{1}{329,8}$
Dunnose,	,0055614	$\frac{1}{323,7}$
Clifton and Arbury Hill,	,0042956	$\frac{1}{229,6}$
London,	,0052590	$\frac{1}{294,9}$
Dunnose,	,0052616	$\frac{1}{295,1}$
Arbury Hill and London,	,0069767	$\frac{1}{597,5}$
Dunnose,	,0060212	$\frac{1}{380,3}$
London and Dunnose,	,0052837	$\frac{1}{297,0}$

From the experiments given in the former part of this Report, it appears probable, that if the uncertainty which must exist in the allowance for the height above the level of the sea be excepted, the error in the number of vibrations of the pendulum, at any particular station, does not amount to so much as one-tenth of a vibration, which is nearly equivalent to $\frac{1}{4000000}$ part of the length of the seconds pendulum. To this degree of accuracy consequently may gravitation be determined by the apparatus I have employed; and in passing through a country composed of materials of various densities, the pendulum may be expected to indicate such variation with very considerable precision.

The diminution of gravity from the Pole to the Equator is derived from the decrease which is observed to take place between any two given latitudes; consequently, if no irregular attraction occurred, the results, computed from different portions of the meridian, should be the same. But it may be seen in the preceding table, that the number expressing the diminution of gravity, from the observations at Unst and Portsoy, is less than that deduced from the arc between Unst and Leith, and that this number goes on increasing to Clifton, diminishes at Arbury Hill, and increases again at London. It may also be remarked, that the diminution of gravity, derived from Unst and Dunnose, is less than that deduced from Portsoy and Dunnose; from all which it seems probable, that in advancing southward, gravity decreases more than it ought to do from theory; that there exists an assemblage of materials of greater density than common in the vicinity of Portsoy, and that the density of the strata to the southward becomes less and less until we arrive at Clifton, where it seems to be considerably in defect.

At Arbury Hill, a sudden increase of gravitation is perceptible, and at the short distance of London, this additional force is no longer sensible. From its intensity, and the limited sphere of its action, it might perhaps be inferred that the disturbing material is of considerable density, and not very distant from the surface.

It must be evident, that nothing very decisive respecting the general ellipticity of the Meridian can be deduced from the present experiments. For this purpose, it is requisite that the extreme stations should comprise an arc of sufficient length to render the effect of irregular attraction insensible; and this effect might be diminished, if not wholly prevented, by selecting stations of similar geological character, and which should differ as little as possible in elevation above the level of the sea.

If, however, some deduction be made for the superior density which it has been remarked exists at Portsoy, the compression $\frac{1}{304}$ deduced from that station and Unst, may perhaps be considered as not far distant from the truth, both being situated on rocks of a similar nature; Unst consisting chiefly of serpentine, and Portsoy of serpentine, slate, and granite; and as $\frac{1}{310}$ the ellipticity given by the experiments at Unst and Arbury Hill, is nearly the same as that resulting from Unst and Portsoy, it would be no improbable conjecture that the sudden increase of gravitation observed at Arbury Hill, may be occasioned by a rock of primitive formation, approaching the surface of the earth in the vicinity of that station *.

These facts appear sufficient to explain the anomalies which have been remarked in the Trigonometrical Survey of Great Britain. For if the disturbing force in the neighbourhood of Arbury Hill, were supposed to be situated to the north of that station, the plumb line would be attracted northward, the observed latitude would be less than the true, and the length of the degree deduced from the arc between Dunnose and Arbury would be in excess, and that derived from the arc between Clifton and Arbury in defect. This last error will be augmented, if we suppose the attraction of the matter near Arbury Hill to be felt at Clifton, and the plumb line at that station to be drawn towards the south.

M. Biot, by a comparison of his numerous experiments at Unst with those made at Formentara and Dunkirk, in conjunction with M. Arago, obtains $\frac{1}{310}$ for the resulting compression. But if the allowance for the elevation of Formentara above the level of the sea, be corrected in the manner suggested by Dr Young, the ellipticity should be about $\frac{1}{319}$. The details of

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* Since the above was written, I find the conjecture I have hazarded remarkably supported by fact; for on consulting Smith's Geological Map of England, it appears that Mount Sorrel, a mass of granite, is situated, together with other rocks of primitive formation, about 30 miles to the north of Arbury Hill.

M. Biot's experiments have not yet been published; but it affords me much gratification to learn, that the acceleration of the pendulum between London and Unst, computed by M. Biot, from his observations at Unst and those at Formentara, using $\frac{1}{310}$ for the compression, differs only $0^{s},6$ from the result of my experiments; a difference which may probably be referred to the superior density of Unst, compared with that of the substrata of London."

Art. XX.—*On the Discovery of Potash in Sea Water.* In a Letter from Dr Wollaston to Dr Marcet [*].

When Dr Marcet was beginning the chemical part of his researches respecting the specific gravity and temperature of sea waters, Dr Wollaston suggested to him the probability that traces of potash might be found in them. In order to examine this point, Dr Marcet supplied him with various specimens of sea water; and in the following note, Dr Wollaston communicated to him the results of his examination.

"The expectation which I expressed to you, that potash would be found in sea-water, as an ingredient brought down by rivers from the decay of land plants, is now fully confirmed by experiments on waters obtained from situations so remote from each other, as to establish its universality.

"There is no difficulty in proving the presence of this ingredient by muriate of platina. For though the triple muriate of platina and potash is so soluble that this reagent causes no precipitate from sea-water in its ordinary state, yet when the water has been reduced by evaporation to about $\frac{1}{8}$th part, so that the common salt is beginning to separate by crystallization, the muriate of platina then causes a copious precipitate.

"If this precipitate be mixed with a little sugar and heated, the platina is reduced, and muriate of potash may be separated from it by water, and the nature of its base shown by its yielding crystals of nitrate of potash with nitric acid.

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[*] From Dr Marcet's paper "On the Specific Gravity and Temperature of Sea-Waters," in the *Phil. Trans.* 1819, p. 200.

"I evaporated a pint of the water which you sent me (marked No. 9. specific gravity 1026.22), taken up by Captain Ross in Baffin's Bay, from the depth of 80 fathoms, latitude 36° 32′, longitude 76° 46′ west. When this had been reduced to about $\frac{1}{20}$th part, I drained the liquor from the salt that had formed, which I also washed with a little water, and, by adding muriate of platina to the drained liquors, I had a yellow precipitate which weighed 12.4 grains.

"As the fluid poured from this precipitate measured $\frac{3}{4}$th of a fluid ounce, I estimate that this would retain in solution about three grains of the triple muriate; and hence the whole amount must be taken at 15.4, which, by former experiments, I consider as equivalent to about 6.4 sulphate of potash, or 3.5 potash. Now, since the pint of water weighed about 7520 grains, $\frac{6.4}{7520}$ gives the proportion of potash, about $\frac{1}{1200}$; but the quantity of mere potash is less than $\frac{1}{2000}$th part of sea-water, at its average density."

Dr Wollaston has also detected traces of potash in the water of the Lake of Ourmia or Arumea, which is unconnected with the ocean. The water of this lake (which is situated in the province of Azerbijan in Persia) is said to be salter than that of the sea, so that no fish can live in it. Dr Wollaston is of opinion, that the potash exists in sea-water in the state of sulphate.

ART. XXI.—*Short Comparison of the Volcanic Rocks of France with those of a similar nature found in Scotland.* In a Letter addressed to Professor JAMESON, by AMI BOUE', M. D. Member of the Wernerian Society *.

DEAR SIR,

HAVING lately spent some time in the remarkable volcanic districts in the South of France, and knowing the interest you have always taken in every thing respecting the geognosy of that country, I now send you a few notes of my observations, expecting at some future period to extend and illustrate them more fully and accurately than I can spare leisure for at present. In making you acquainted with some of the geognostical phenomena I met with, probably a sufficiently intelligible mode will be to institute a comparison between the rocks of the districts in question, and those that occur in Scotland, particularly in the vicinity of Edinburgh.

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* I have much pleasure in laying before our readers the interesting letter of my friend and former pupil Dr Boué. During his residence in Scotland, he visited and examined many extensive tracts of country, and studied particularly

1. Between Edinburgh and Glasgow, near Calder, there is a quarry of a black compact basalt, which contains grains of olivine and crystals of augite. This rock cannot be distinguished from the basalt of Montaudoux, near Clermont, in Auvergne *. This small hill is considered by Montlosier, Raymond, Lacoste, &c. as part of a very ancient stream of lava, (coulée,) and is intimately connected with other masses of ancient volcanic formation.

2. At Apchon there is an alternation of basalts, tuffas, and lithomarges: These various substances and their arrangements are much the same as what occur at the Giant's Causeway in Ireland, and yet here, according to geologists, the whole series is of volcanic formation.

3. The porphyry-slate on the north-west borders of the Mont d'Or, which is of a volcanic nature, bears a striking resemblance to that of the Island of Lamlash, in the Frith of Clyde. The same is the case with the porphyry-slate of the Mezen, and of other parts; and it is worthy of remark, that these rocks in France pass into trachyte or volcanic porphyry, and sometimes contain fragments of undoubted scoriæ. The rock of the Dalmahoy Hills near Edinburgh, has the same basis as the volcanic porphyry rocks of Mont d'Or, and like them contains acicular and large crystals of felspar and crystals of augite. The porphyry-slate of North Berwick Law, and of Traprain Law, resembles the porphyries of Mezen and Mont d'Or, but the re-

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our trap-rocks. Another of my pupils Dr Daubeny, also distinguished for his activity and intelligence, and who has examined much of Scotland, has lately spent some time in Auvergne, and will, I trust, soon favour us with an account of his observations. Dr Ogilby, one of my early pupils, now in France, will also visit Auvergne.
R. J.

* Buch's Geognostische Beobachtungen, &c. T. 2. p. 235.

semblance is not so great as in the rock of Lamlash. The porphyries of the Girleton Hills, near Haddington, bear only a slight resemblance to those of the Mont d'Or, while the varieties found in the Pentland range, are of a different nature.

4. The greater part of the rocks of Arthur Seat have the same arrangement, and are of the same species as those in the volcanic districts of Auvergne and the Vivarais. The form of the hill, its rising suddenly in the midst of a comparatively flat country, its terraced aspect, its various lava-like rocks, and other circumstances, would seem to shew that it has been a *submarine volcano.* But the rocks of Salisbury Craig are of a different nature. I did not meet with any greenstone rock like that of the Craig, in the volcanic country of France, nor any lava, which contained such quartz-crystals, and iron-stone veins, as occur in this greenstone. The same is the case with the greenstone rock on which Stirling Castle is built. The only place where I saw a rock, which, on a general view, had some resemblance to your greenstones, was at Roffiat near to St Flous, where it occurred in the middle of a stream of basaltic lava. It seemed to be a distinct compound of felspar and augite, but was without crystals of olivine.

5. I examined very carefully the different basaltic veins (whin-dikes,) that occur in the districts over which I travelled. Near Murat in the Cantal, I found a pretty broad basaltic vein running from top to bottom of a hill, composed of a volcanic tuffa, including much porous lava, and capped with beautiful basalt pillars. The veins contain elongated cavities, some of which are entirely filled with calcareous spar and arragonite? while others were only lined with small wax-yellow crystals, of a substance called Mellilite. At St Jaques, at the foot of that porphyritic mass the Plomb du Cantal, I found a porphyritic vein, running through a white-coloured volcanic tuffa. The vein was porphyritic basalt. It was partly amygdaloidal, and many of the amygdaloidal cavities were lined with calcareous spar, others with a matter like green earth. It appeared to contain small grains of iron-pyrites and of augite. But I did not find any rock precisely similar in my collection of Scotch specimens, notwithstanding many of your basaltic veins are disposed, as is the case with this one, in small ho-

rizontal columns. Near to the top of the part which unites the Col de Cabra with the Puy Marie, I had the pleasure of observing three fine basaltic veins, traversing a pretty porous trachyté or volcanic porphyry. The porphyry is of a red colour, and contained numerous small crystals of glassy felspar. The middle vein is about one foot and a half broad, and is composed of a very black, compact, dull, heavy basalt, inclosing grains of olivine, and perhaps also of augite. The vein to the west of this is one foot wide, and the third to the east three feet; and between this last and the middle one, there is still another, about half a foot wide. Not far from these veins there are vertical sections of streams of basaltic-lava, which rest upon immense inclined beds of various kinds of volcanic tuffa, in which there are occasionally found masses of basalt, bearing a great likeness to that which forms the veins. But one of the most interesting of these veins I examined, was observed at Villeneuve Le Berg, traversing limestone. The basalt has nearly the same characters as that of St Jacques; it contains many crystals of augite, and is sometimes amygdaloidal, and the cavities are filled with calcareous spar, or lined with iron-pyrites. The limestone, where in contact with it, is rendered more compact; and the same is the case with the numerous pieces of limestone contained in the vein, particularly towards its crop or outgoing. But in no instance is the limestone crystallised or changed into marble; all I could observe was a simple hardening of a rather earthy looking limestone. I examined the *contact-limestone*, with the view of ascertaining if in any case it would not effervesce with acids, but I found all the varieties, even the most compact, effervesced with acids. In favour of what theory is this fact? I dare not adopt the filling up from above, it is attended with so many difficulties; but the volcanic hypothesis of injection into a rent is somewhat countenanced by the great accumulation of fragments towards the crop of the vein; its mode of termination near the surface, and several other circumstances.

6. On visiting Auvergne, I expected to obtain some satisfactory ideas in regard to your Scottish pitchstones, particularly those of the Island of Arran, but have returned with only a single fact, viz. that veins which are partly of basalt, partly of

pitchstone, as in the Valley des Gardes in the Cantal, along with two other basalt veins, traverse trachyte or volcanic porphyry. (Vid. La Coste's *Lettres sur les Volcans d'Auvergne*, p. 255.) Not having the specimens I collected at this moment beside me, I cannot affirm that the rocks are identical with the remarkable pitchstone veins which you discovered on the eastern extremity of the Isle of Lamlash, although I am convinced that they are nearly of the same nature. All the other minerals in the Cantal group which have been referred to the pitchstone species, appear to me to be varieties of semi-opal. Some of them are found in irregular beds in the calcareous fresh-water formation, and these appear to pass into *Menilite*, while others occur in large masses in volcanic tuffa. These latter appear to be singular siliceous volcanic productions, that bear some relation to the volcanic rocks of Hungary. At St Pierre Eynat, in the Mezen group, semi-opal occurs in concretions, in what appeared to me, during my cursory visit, to be a fresh-water formation. In the Mont d'Or group is a resinous-like mineral, which has been considered as a variety of pitchstone, and it is so arranged in the Royal Museum of France, under the name *Retinite porphyritique et subretinite*. I am quite satisfied of the resemblance of these to your pitchstone-porphyry, but they are by no means identical with it. We must, I think, look for illustrations in Germany and other countries; for the single fact just mentioned, although *ad hoc*, is not sufficient to decide the question about the pitchstone.

7. The next rock I shall mention is the *Trachyte*, or volcanic porphyry. Under this name are comprehended many different porphyritic rocks, having the general character of containing crystals of glassy felspar. It is almost impossible to give a definition of such a rock; and how could it be otherwise with a volcanic production, which is formed from all the different members of the granite formation? The porphyry rock of Drumadoon Point in Arran bears some resemblance to trachyte: in some parts of the Croix Morand, in the Mont d'Or group, I found specimens which recalled to my mind the green and more compact parts of the trap-porphyry of Rue Varey Point, also in Arran. But still the structure and position of the Arran porphyries, on a general view, are so different, that

we cannot identify them with the true trachytes. But this is a point which must be determined by you.

I have only further to remark, in regard to the trachyte, that some of the varieties found in masses in volcanic tuffa, brought to my recollection certain porphyries of the Braid Hills near Edinburgh. This, however, may possibly prove but an accidental resemblance; and this is the more likely as the Braid Hills, Blackford Hill and Pentland Hills, which you point out as members of the same series, differ in many things from true trachyte districts.

8. I did not observe any where in the volcanic districts of Auvergne and the Vivarais, rocks like the greenstone forming the great vein in the coal-field to the N. E. of the Calton Hill, nor any which corresponded with the following, viz. the greenstone of Corstorphine Hill and of Cramond; the greenstones of Burntisland in Fifeshire; the greenstone of the Pentlands; the clinkstone-porphyries of Dunbar; the Invergourie rocks near Dundee; the trap-rocks of Renfrewshire. Yet still our knowledge of volcanic-rocks is so imperfect, that we cannot maintain that all these, and others of the same description, are of Neptunian origin.

9. Nowhere in the volcanic districts, already so often mentioned, did I find any amygdaloidal rocks resembling those of the Pentlands, Montrose, and other parts of Scotland. The only rock which made an approach to these, was that of the Puy Giroud near Clermont.

In conformity with the preceding, and indeed with other observations to be communicated to you, I would propose arranging your trap-rocks in the following manner, according to their probable origin.

* *Evidently Volcanic.*

1. Calder basalt, and the one resembling it which I found near Edinburgh.
2. The Giant's Causeway.

** *Probably Volcanic.*

1. Staffa. 2. Some parts of the Island of Mull. 3. Arthur Seat, in part. 4. Dalmahoy Hills. 5. Lamlash Isle. 6. The trap-veins in Arran, and in the neighbouring districts in Ireland

and Scotland. 7. The Dumbarton and Frisky Hall rocks, and some Renfrewshire rocks. 8. Craig Lockhart. This remarkable rock has much the appearance of a volcanic tuffa, formed in some measure by means of volcanic water.

*** *Doubtful Rocks.*

1. Castle Rock of Edinburgh and the Calton Hill. 2. Stirling Castle rock. 3. Salisbury Craig. 4. Blackford Hill. 5. North Berwick Law, Traprain Law, and Girleton Hills. 6. The rock of Rue Varey Point in Arran. 7. Some trap-rocks of Linlithgow. 8. The pitchstones of Arran. 9, and lastly, The amygdaloids and claystones.

ART. XXII.—*On the Optical Properties and Mechanical Condition of Amber.* By DAVID BREWSTER, LL. D. F.R.S. Lond. & Edin., &c.

THE nature and origin of *Amber* have afforded to naturalists a fertile subject of controversy; and, after all that has been written on the subject, it is difficult to say whether it is the prevailing opinion that amber is a mineral body, an indurated vegetable juice, or a mineral oil inspissated by chemical causes, or by the slow operation of time.

The general resemblance of amber to *Mellite*, which is a regularly crystallised body, and its occurrence at considerable depths in the earth, have induced most mineralogists to give it a place in their system next to this mineral: while its resemblance to indurated gums; its want of all appearance of crystalline structure; its occurrence in a stalactitical form, in strata of half decomposed trees; and the circumstance of its containing insects and vegetable remains, have given no inconsiderable degree of probability to the opposite opinion.

In my early experiments on Depolarisation, I found that *Amber* possessed the particular organisation which gives bands of complementary colours by polarised light*, and that it sometimes had such a regular structure, as to exhibit distinct neutral and depolarising axes. I had frequently occasion to recur to the examination of this substance when any interesting specimen presented itself; and having now examined almost every variety which is likely to occur, I trust that the results which I have obtained, will be considered as throwing some light on the origin and formation of this interesting body.

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* See *Phil. Trans.* 1814, p. 214, and 1815, p. 37.

1. In several specimens of *Amber*, the polarising structure existed in such a manner as to display itself in irregularly parallel zones of colour, which suffered no change by altering the external shape of the mass. These different zones had their axes lying in different directions, so that some of them were dark when others gave the tints of the first order, and *vice versâ*. Hence it is obvious, that the axes of these zones must have been inclined 45° to each other; that this structure must have been acquired during the gradual induration of the amber, and must have had its character modified according to the nature of the juice which was successively deposited round the nucleus. The limits, or lines of junction, of these zones appeared even in common light, and could not have been produced either by heat or pressure. Some of these specimens of amber displayed variously inflected veins of different degrees of transparency like the agate, and in many cases the tints rose to the green and red of the second order. The streaks which gave the highest tints, were in general yellower than the rest of the mass.

2. In some specimens of amber of a rectangular shape, I observed the same polarising structure which exists in plates of glass gradually heated or rapidly cooled, namely, a negative between two positive structures. This structure must have been acquired during the gradual induration of the amber at all its surfaces.

3. A cylindrical piece of amber, which was cut out of a bead, gave the black cross and the coloured tints exactly like a cylindrical piece of glass that had been heated to redness and rapidly cooled, as represented in the *Edin. Trans.* vol. viii. Plate VII. Fig. 10. The thickness of this piece was about $\frac{2}{10}$ths of an inch, and its highest tint was the yellow of the first order.

4. In a piece of amber of the same thickness as the preceding, the polarising structure had suffered a change by drilling a hole through its centre; and in numerous specimens, I found that

the polarising structure could be altered by changing their forms, though not to the same degree as in plates of crystallised glass. In some specimens, a negative structure is developed round the perforation, as in tubes of glass *.

5. Along the axis of a fine stalactite of amber containing insects, I discovered that remarkable structure which occurs in quartz, and produces the phenomena of circular polarisation, the tints descending in the scale as the analysing prism was turned from right to left. This stalactite was 1½ inches long, and about 1 inch in diameter, and did not polarise the usual tints beyond the yellow of the first order.

6. Some specimens of amber did not possess the polarising structure in the slightest degree, and in this respect resembled *Gum Copal*, *Gum Galbanum*, *Gum Juniper*, and *Gum Mastic.* All specimens of this kind must have been indurated very slowly, and in such an uniform manner that the induration went on with equal rapidity in the interior as at the exterior surface of the mass.

7. Every specimen of amber is capable of having its polarising structure altered, or a new polarising structure communicated to it, by heat, or by mechanical compression or dilatation.

8. In pieces of amber filled with globules of air, a polarising structure indicated by four minute sectors of polarised light is developed round the globules, by the pressure arising from the expansive force of the included air.

These results, obtained from a very extensive examination of specimens, appear to establish beyond a doubt, that *Amber* is an *indurated vegetable juice*, and that the traces of a regular structure, indicated by its action upon polarised light, are not the effect of the ordinary laws of crystallisation by which *Mellite* has been formed, but are produced by the same causes which influence the mechanical condition of Gum Arabic, and other gums which are known to be formed by the successive deposition and induration of vegetable fluids.

EDINBURGH, *Feb.* 18. 1820.

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* See *Edin. Trans.* vol. viii. p. 362.

Art. XXIII. *Account of the remarkable Depression of the Thermometer, and Rise of the Barometer, in January* 1820.

The meteorological facts which presented themselves in the month of January 1820, are so singular in themselves, and have been so unprecedented in this climate, that we have thought it advisable to record some of the best authenticated observations.

1. *Observations made at Perth.*—On the night between Monday 17th and Tuesday 18th January, (the coldest night perhaps ever remembered in this country), the thermometer stood at Perth, in a northern exposure, so low as —10° on Fahrenheit's scale, being not less than 42° below the freezing point. During the whole of Tuesday, the instrument remained under zero, except for a short interval about noon, when it rose to 1°. The effects of this great reduction of temperature were such as usually accompany the most intense cold. The evaporation from the surface of the ice on the Tay, being condensed in the air almost immediately after its formation, produced over the river a partial fog, which, being gently wafted to the neighbouring trees, attached itself by degrees to the branches, and gave birth to innumerable and diversified exfoliations of the most singular beauty. The bridge being elevated above the vapour, a remarkable appearance was observed, during sunshine, by a spectator who raised his head a little above the parapet, so as to throw his shadow on the fog below: a gigantic figure was seen projected on the moving vapour, (such as has been frequently noticed under similar circumstances, in Alpine countries,) surrounded by a beautiful *halo*, and throwing off, in every direction, radiations which exhibited distinctly all the prismatic colours. The effect was most striking when the sun was a few degrees above the horizon, and was barely perceptible after mid-day. So great was the intensity of the cold, that the windows of apartments where a constant fire was kept, were covered with a thick coating of ice, which obscured the light of day; and liquors of various kinds were completely frozen, in situations where it might have been supposed they were beyond the reach of frost. The sudden increase of temperature which took place from Tuesday

to Wednesday, is scarcely less remarkable than the unusual cold which it succeeded, the mercury having risen in the course of 24 hours, nearly 40°, and indicated a transition fully as great as if we had passed, in that short interval, from the ordinary cold of winter to the extreme heat of summer.

We have thus witnessed, within the short space of ten days, two remarkable meteorological phenomena: the greatest atmospherical pressure, and the most depressed temperature that have probably ever been observed, or at least that have ever been recorded, in this part of the island. The conditions of the atmosphere which led to this unusual state of things, have, it may be concluded, produced a mutual re-action on each other; the comparatively great cold which preceded the high state of the barometer, by condensing the aerial columns over this country, would cause a current of air to flow from all the contiguous regions to supply the deficiency in the equilibrium, and raise accordingly the barometer; and, on the other hand, the subsequent diminution in the pressure, amounting in a few days nearly to 2 inches, by allowing the air to expand itself, appears to have caused a powerful absorption of caloric, in consequence of the sudden dilatation, and thus added greatly to the intensity of the cold.

The cold seems to have been fully more intense in this neighbourhood than in any other part of the kingdom. Indeed it does not appear, by the meteorological records in the Phil. Trans. for 150 years back, that it has ever been much exceeded in any part of Europe, excepting Russia and Sweden. In the severe winters of 1683, 1709, 1715, 1740, and 1768, the thermometer never descended below —2°; nor do we find a well authenticated instance of its being lower in Britain during any other year, than it stood here on the night of Monday the 17th instant, unless in 1780 *, when it was observed by Dr Wilson, at Glasgow, 14° below zero, or 4° lower than it was seen at this place.

Perhaps no circumstance is better fitted to illustrate the extreme severity of the late frost, than the fact of water freezing in our apartments, from 24 to 36 hours after the thaw began, and when the external air was nearly 10° above the freezing

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* This remarkable cold happened on Friday the 14th January, at 6 A. M. See *Phil. Trans.* 1780, p. 451.—Ed.

point. This curious fact, which it would have been difficult to explain in ordinary cases, was evidently owing to the walls retaining a temperature below the freezing point, for a considerable time after the air had reached the temperature of 40°, and radiating the cold with which they were impressed to the contiguous bodies.

Had the cold been of longer duration, or less interrupted by occasional remissions in its severity, its physiological effects would have been more remarkable. During the short time it continued, several instances occurred in the vicinity of Perth, of persons perishing by its intensity; domestic animals were found frozen to death, in attitudes which proved the sudden cessation of their vital functions; and, in some cases, the trunks of the largest trees were reft from top to bottom, by the congelation of their juices, in the same manner as if they had been shivered by lightning. The damage, in fact, that has been done to standing timber, particularly to oaks, elms, and ashes, is probably greater than can be easily ascertained, as many of these trees, which were a good deal split, have again closed so completely since the commencement of the thaw, that the fissures cannot now be discovered without a very minute inspection. The effect, however, will be more apparent afterwards, by the longitudinal ridges which will appear in the bark.

We have already seen, that a very sudden and extensive change of temperature, amounting to 40°, occurred from Tuesday to Wednesday the 19th: On the morning of Saturday the 22d, we experienced another instance of the same kind, and still more illustrative of the extreme variableness of our climate, the thermometer having risen from one degree below zero to 30°, in the course of three hours. This change in natural temperature, which took place here between 8 and 11 o'clock in the forenoon of that day, is so remarkable, that it deserves to be recorded among the peculiarities of this uncommon season. About 3 o'clock in the afternoon the thaw commenced.

2. *Observations made at Kinfauns near Perth.*—The following interesting observations upon the state of the Barometer and Thermometer were made at Kinfauns by the Reverend Robert Gordon, who, when he observed the barometer above the usual height, and still rising, registered it at intervals during the whole day.

BAROMETER.

		Temper.	Pressure.
7th January 1820,	10 morning,	38.0	30.198
	10 evening,	38.4	30.510
8th, ——— ———	10 morning,	37.5	30.680
	12 noon,	38.7	30.697
	2 afternoon,	38.5	30.710
	4	38.5	30.730
	6	38.0	30.745
	7	38.0	30.765
	9	38.0	30.787
	10	39.0	30.800
	11	38.5	30.810
9th, ——— ———	9 morning,	36.0	30.845
	10	36.0	30.835
	10 evening,	36.0	30.665

The highest observed was at 9 in the morning of the 9th; but it is probable it had been higher during an earlier part of that day.

The lowest temperature during the night between the 8th and 9th, was 18½°. In several days after, the thermometer did not sink below 27°. On the night between the 16th and 17th, it sunk to 13½°, and during the next night, or rather on the morning of the 18th, it was at zero, which was the lowest at Kinfauns.

The following is the state of the THERMOMETER observed by Mr Gordon on the 18th January 1820:

Lowest previous to 8¾ morning,	0°.0	at 2 afternoon,	10°.5
at 8¾ morning,	2.5	3	10.0
9	3.0	4	8.0
9¾	7.0	5	9.0
10	6.0	6	7.5
10¼	5.0	7	9.0
11	9.0	9	8.0
11½	8.0	10	10.5
12	10.0	midnight,	13.0
1 afternoon,	11.0	On the morning of the 19th at 10,	27.5

The barometer during the 18th sunk gradually from 29.425 at 10 morning, to 29.245 at 10 evening. The elevation of this place is 185 feet, so that the barometer at the level of the sea must have been as high as 31.045, on the 9th.

3. *Observations made at Strathallan in Perthshire and other places.*—At Strathallan, situated about two miles to the west of Auchterarder in Perthshire, the Thermometer stood at 13° below zero during the night of the 17th. At 9 o'clock in the morning it stood at —10°, and it never rose more than 1° above zero the whole day.

At Colquhalzie in Perthshire, the Thermometer was observed at 10° below zero, at 9 o'clock on the 18th. At Crieff it stood at 12° below zero; and on the south of the Ochill Hills it was also at 10° below zero.

4. *Observations made at Leith.*—The following observations were made at Hermitage Hill, near Leith, by Andrew Waddell, Esq. F. R. S. E. The Barometer was 60 feet above the level of the sea.

1820.		9 A. M. Inches.	10 P. M. Inches.
January	7.	30.310	30.680
	8.	30·780	30.925
	9.	30.999	30.770
	10.	30.670	30.350
	11.	30.055	30.080
	12.	30.260	30.260
	13.	30.140	30.320
	14.	30.300	29.800
	15.	29.850	29.750
	16.	29.675	29.520
	17.	29.540	29.520
	18.	29.500	29.130
	19.	28.890	29.190
	20.	29.270	29.480

The following was the state of the Thermometer, as observed also by Mr Waddell:

1820.		Highest in the Day.	Lowest in the night.
January	16.	30°	13°
	17.	20	4
	18.	15	13
	19.	28	18
	20.	30	25

The cold was marked by a spirit thermometer, which was as low, at 9 A. M. on the 17th, as it had been during the night. The mercurial thermometer at this time stood at 3°, and when another mercurial thermometer was laid on the snow, it fell below zero.

Art. XXIV.—*On Steam, and the Sediment of Water found in the Boilers of Steam Engines.* By Robert Bald, Esq. F. R. S. E. Communicated by the Author.

In collieries where the common steam-engine is applied for drawing water from the mines, it frequently happens, that after a continuance of wet weather, the water accumulates so much, as to require the engine to be wrought night and day. If the boiler is supplied with water from the mines, it contains in this case a great quantity of earthy matter brought immediately from the surface, which renders the water within the boiler very muddy; and there being little time for cleaning the boiler, owing to the accumulated water in the mines, six or eight weeks sometimes elapse before this can be done. Towards the end of this period the water in the boiler is mixed with sediment to such a degree, that the ordinary supply of steam cannot be raised, although the fire is increased in the furnace; the consequence of which is, that the common working speed of the engine is greatly reduced. In this case it has been the constant practice of the engine-keepers in Scotland to apply a very simple remedy for increasing the quantity of steam.

The substance employed is known by the name of *Comings*, being the radicles of barley produced in the process of malting, which are separated before the malt is sent to market. About a bushel of these is thrown into the boiler; and when the steam is again raised an immediate effect is visible; for there is not only a plentiful supply of steam to produce the full working speed of the engine, but an excess of it going waste at the safety valve. This singular effect will continue for several days. Such is the fact,—but the principles by which this vegetable matter acts, are not very obvious, as it is doubtful whether it acts chemically or mechanically. If its action is mechanical, chaff or saw-dust may produce the same effect.

In the distillation of ardent spirits upon a great scale, it is found necessary, when converting the fermented liquor or wash into low wines, to throw a quantity of soap into the still every time it is charged or filled, which has the effect of causing the steam to rise more quickly, and more disengaged from the residuary matter of the process. In this instance the soap acts chemically, by uniting with the water and residuary matter. We do not, however, see any analogy between this process and the effect produced in the engine-boiler before mentioned.

The sediment in boilers produced after wet weather, is chiefly composed of clay, and does comparatively little injury to the boiler; but in general the common mine water which percolates very slowly through the strata, produces a sediment of sulphate of lime, which adheres so closely to the bottom of the boiler that it cannot be removed, but by picking it off with a sharp iron instrument; and this sediment, when removed, has frequently a thin scale of the iron-plate of the boiler adhering to it. In this way the boiler is not only injured, but if the sediment accumulates at any part of the bottom, the plates are liable to become red hot at that place, which greatly injures them.

To lessen these injurious effects, it is the practice to throw into the boiler a quantity of *peat-earth*, in its natural plastic state, which is found to have a considerable effect in preventing the sediment from adhering so closely to the boiler plates.

ALLOA, *February* 8. 1820.

ART. XXV.—*On the Absorption of Polarised Light by Doubly Refracting Crystals* [*]. By DAVID BREWSTER, LL. D. F. R. S. Lond. and Edin.

THERE are no phenomena in optics which are less understood than those which relate to the *Absorption of light*, or that property of transparent bodies by which they detain and assimilate to their own substance a portion of the light which penetrates them. It became, therefore, a matter of great importance to discover in regular crystals some analogous phenomena, where the absorptive power acted in relation to certain fixed lines in their crystalline form, as it was only by such a discovery that philosophers could expect to investigate the general subject with any hopes of success. A series of phenomena of this kind presented themselves to the author of this paper when he was studying the polarising structure of super-acetate of copper, and having been thus led to examine other artificial crystals and minerals, he found that the phenomena were much more general and important than he had at first supposed.

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[*] Abridged from the *Philosophical Transactions* for 1819, page 11.

If we take a prism of *Beryl* of a *bluish-green* colour, and expose it to light polarised, either by transmission through Iceland-spar*, or by reflection from glass at an angle of 57°, we shall find that it transmits only a beautiful *blue* light when its axis is perpendicular to the plane of polarisation, and only a *greenish-white* light when the axis coincides with that plane, the transmitted light passing from the former to the latter tint, while the crystal is moving from the first into the second position. Hence it is obvious that the *green* light is absorbed in one position, and the *blue* light in the other position. Now, this absorption varies with the angle which the polarised ray forms with the axis of the prism, being a maximum when that angle is 90°, and vanishing altogether when the ray passes along the axis.

If we now cut the crystal of beryl into a prism, so as to separate the two images which it forms by double refraction, we shall find that these two images have different colours, the one image having the same colour that would have been produced by exposing it in one position to polarised light, and the other image having the colour that would be obtained by turning it round 90°. Here, then, we have two singular properties of this class of crystals, which always appear to accompany one another, viz. the property which the extraordinary refracting force possesses of selecting certain rays out of the compound beam of common incident light, and the property of absorbing these rays in one position, and the supplementary rays in another position, when the incident light has been previously polarised.

The property which has now been described as belonging to *Beryl*, I have found in other twelve crystals with *One axis*. The colour of the ordinary and extraordinary images, or of the absorbed pencils, is shown in the following table.

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* See this *Journal*, vol. i. p. 290. and vol. ii. p. 170.

List of Absorbing Crystals with One Axis.

Names of Crystals.	Colour when its axis is in the plane of primitive polarisation.	Colour when its axis is perpendicular to that plane.
Zircon	Brownish white	A deeper Brown
Sapphire	Yellowish green	Blue
Ruby	Pale yellow	Bright pink
Emerald	Yellowish green	Bluish green
Emerald	Bluish green	Yellowish green
Beryl blue*	Bluish white	Blue
Beryl green	Whitish	Bluish green
Beryl yell. green	Pale yellow	Pale green
Rock crystal, almost transparent	Whitish	Faint brown
Rock crystal yell.	Yellowish white	Yellow
Amethyst	Blue	Pink
Amethyst	Greyish white	Ruby red
Amethyst	Reddish yellow	Ruby red
Tourmaline	Greenish white	Bluish green
Rubellite	Reddish white	Faint red
Idocrase	Yellow	Green
Mellite	Yellow	Bluish white
Phosp. of lime (lilac)	Bluish	Reddish
———— olive	Bluish green	Yellowish green
Phosphate of lead	Bright green	Orange yellow
Calcareous spar	Orange yellow	Yellowish white

The property which these crystals possess of absorbing the different tints in different positions of the axis, with regard to the plane of primitive polarization, does not belong to every specimen. There are many crystals of ruby, sapphire, emerald, &c. which give an ordinary and an extraordinary image of the same colour; and whenever this is the case, they are destitute of the property of absorbing polarised light. These two classes of phenomena are indeed invariably connected, and will ultimately be found to have the same origin.

Some of the preceding crystals, such as the *Sapphire* and the *Idocrase*, exhibit different colours when common light is transmitted in directions parallel and perpendicular to their axis of double refraction. A specimen of *sapphire* had a *deep*

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* There are two magnificent crystals of *Beryl* in the possession of Mr Sanderson, which exhibit the phenomena of absorption in a most beautiful manner. Both of them absorb a fine deep *blue tint* when the axis is in the plane of polarisation, and a greenish *white tint* in a rectangular direction. A knowledge of these properties of precious stones is necessary, to discover the proper mode of cutting them for the purposes of jewellery.

blue colour in one direction, and a *yellowish-green* in the opposite direction; and several specimens of *idocrase* had an *orange-yellow* tint along their axis, and a *yellowish-green* tint in a direction perpendicular to their axis. The exhibition of two colours in the same mineral by common light, was first seen in *Iolite*, and the Abbé Haüy had the boldness to give it the name of *Dichroite* from this property, on the presumption that nature had limited it to this mineral.

In crystals with two axes the preceding phenomena receive some curious modifications, for a particular account of which we must refer to the paper itself. The two colours which appear in the ordinary and extraordinary pencils are now seen diverging rectangularly from the resultant axes of the crystal; and this effect, when seen in dichroite, constitutes one of the finest appearances in optics. The two streams of blue light which issue from its poles of no-polarisation, are finely contrasted with the bluish-white beams which diverge from the same poles *.

The following table contains the tints in several crystals, in which the effect will be seen in every azimuth.

List of absorbing Crystals with Two axes.

	Plane of the resultant axes in the plane of prim. polarisation.	Plane of the resultant axes perpendicular to the plane of prim. polarisation.
Topaz blue	White	Blue
——— green	White	Green
——— greyish blue	Reddish grey	Blue
——— pink	Pink	White
——— pink yellow	Pink	Yellow
——— yellow	Yellowish white	Orange
Sulphate of barytes		
——— yellowish purple	Lemon yellow	Purple
——— yellow	Lemon yellow	Yellowish white
——— orange yellow	Gamboge yellow	Yellowish white
Kyanite	White	Blue
Dichroite	Blue	Yellowish white
Cymophane	Yellowish white	Yellowish
Epidote olive green	Brown	Sap green
——— whitish gr.	Pink white	Yellowish white
Mica	Reddish brown	Reddish white

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* For an account of the method of cutting the *Dichroite* to see this effect, and of the remarkable properties of *super-acetate of copper*, *augite*, *mica*, &c. the reader is referred to the original paper.

The following table shows the characters of the tints in crystals with two axes, which have not been examined in every azimuth.

	Axis of prism in the plane of primitive polarisation.	Axis of prism perpendicular to the plane of primitive polarisation.
Mica	Blood red	Pale greenish yellow
Acetate of copper	Blue	Greenish yellow
Muriate of copper *	Greenish white	Blue
Olivine	Bluish green	Greenish yellow
Sphene	Yellow	Bluish
Nitrate of copper	Bluish white	Blue
Chromate of lead	Orange	Blood red
Staurotide	Brownish red	Yellowish white
Augite	Blood red	Bright green
Anhydrite	Bright pink	Pale yellow
Axinite	Reddish white	Yellowish white
Diallage	Brownish white	White
Sulphur	Yellow	Deeper yellow
Sulphate of strontites	Blue	Bluish white
——— cobalt	Pink	Brick red
Olivine	Brown	Brownish white

In the last eight crystals of the preceding table, the tints are not given in relation to any fixed line.

The following table contains the characters of the two pencils in crystals, the number of whose axes I have not yet determined.

Phosphate of iron	Fine blue †	Bluish white
Actinolite	Green	Greenish white
Precious opal	Yellow	Lighter yellow
Serpentine	Dark green	Lighter green
Asbestos	Greenish	Yellowish
Blue carb. of copper	Violet blue	Greenish blue
Octohedrite *(one axis)*	Whitish brown	Yellowish brown

Several of the preceding crystals which have a laminated structure, such as mica, epidote, &c. or such as have an imperfect transparency from a defective aggregation of their elementary crystals, frequently exhibit their absorptive qualities, and also their system of coloured rings, by exposure to common light. The light is, in these cases, analysed in passing oblique-

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[*] The tints are given in relation to the short diagonal of its rhomboidal base.

[†] When the axis of the prism was in the plane of primitive polarisation.

ly through the laminæ, in the same manner as if it had been transmitted through a bundle of glass plates *.

Influence of heat in modifying the absorbent power of crystals.

" Having selected several crystals of *Brazilian topaz*, which displayed no change of colour by exposure to polarised light, I found, that after bringing them to a red heat, or even boiling them in olive oil or in mercury, they experienced such a change in their structure, as to exhibit distinctly the power of absorbing polarised light. I next took a topaz, which had one of its two pencils yellow, and the other pink. By exposing it to a red heat, the heat acted more powerfully upon the extraordinary than upon the ordinary pencil, discharging the yellow colour entirely from the one, and producing but a slight change upon the pink colour of the other.

In the formation of pink topazes by heat, it has always been supposed, that the yellow colour is actually changed into pink; but this is quite a mistake, for the pink colour must previously exist in a state of combination with the yellow, and must either form the colour, or exist in the colour of one of the pencils produced by double refraction. The heat does no more than discharge one colour, and leave the other almost unimpaired. This result is of considerable practical importance to the jeweller, as it enables him to determine beforehand, whether or not any topaz will receive a pink colour from heat; for if this colour exists in one of its images, which will in general be seen by exposing it to a polarised ray, he may predict with certainty the success of his experiment.

When a topaz possessing a pink tint has been taken from the fire, it is at first perfectly colourless, and acquires the pink colour gradually in the act of cooling. By exposing it repeatedly to the action of a very intense heat, I have never been able either to remove or to modify this permanent tint.

With the view of ascertaining if the absorbing structure could be induced by heat, I exposed to a white heat several crystals of yellowish calcareous spar. After the action of the fire had been continued for some time, a sort of opalescence, or milky opacity, was induced; and the light, which went to the formation of the ordinary image, was much redder than that which formed the extraordinary ray. This effect I naturally ascribed to some change in the state of the carbonic acid; and upon continuing the action of the heat, and watching the process of decomposition, I found that when the carbonic acid was expelled from a film about the 200th part of an inch thick, its surface was covered with *vesicles arranged in straight lines parallel to the short diagonal of the rhomboid.* These vesicles had, in general, an elliptical form, with a cut or opening in the direction of their transverse axis through which the gas had escaped. After the spar was taken from the fire, a great number of the vesicles burst with a noise similar to that which accompanies the bursting of the indusium of the fern, and carried off a portion of the thin calcareous pellicle. When this pellicle was removed, the subjacent surface was covered with a series of minute parallel grooves inclined about 20° 57′ to the short diagonal. In repeating this experiment, and seizing the proper time for withdrawing the spar from the fire, I never failed to observe the fact of the arrangement and bursting of the vesicles; and I have no hesitation in concluding, that the carbonic acid is arranged in planes passing through the axis of the crystal, a result which I had formerly assumed in explaining the phenomena of double refraction. This method of studying the structure of bodies by watching them in the process of disintegration, may be found to have a very extensive application in chemical and mineralogical inquiries.

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* The oxidated surfaces of steel, and other metals, absorb polarised light in a manner analogous to crystals, as will be minutely detailed in a subsequent memoir on Metallic Polarisation.

The observations contained in the preceding pages, indicate in a manner by no means equivocal, that the colouring particles of crystals, instead of being indiscriminately dispersed throughout their mass, have an arrangement related to the ordinary and extraordinary forces which they exert upon light[*]. In some specimens the extraordinary medium is tinged with the same colouring particles, and with the same number of them as the ordinary medium; but in other specimens of the same mineral, the extraordinary medium is either tinged with a different number of particles of the same colour, or with a colouring matter entirely different from that of the ordinary medium. In certain specimens of topaz, the colouring matter of the one medium is more easily discharged than that of the other; and in two specimens of *emerald*, the colouring matter which tinges the ordinary medium in the one, tinges the extraordinary medium in the other, and *vice versa*.

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[*] Several new facts relative to the arrangement of the colouring matter in crystals, will be found in the *Edin. Trans.* vol. ix. p. 113., now in the press.

All those crystals in which the colouring matter of the one medium differs from the other, either in character or intensity, possess the property of absorbing the two tints according to the laws already mentioned, but there is also reason to believe, that polarised light suffers the same kind of absorption in those crystals whose two images have the same tint, and even in those which are perfectly colourless *."

Art. XXVI.—*Account of the Manufacture of Mosaic at Rome, and History of the Antique Marbles, Alabasters, &c. at Rome.* By W. A. Cadell, F. R. S. L. & E., M. W. S. †

THE art of forming mosaic pictures of tesselated, that is to say, quadrangular pieces of enamel, was practised by the ancient Romans. It was in high repute during the middle ages, and still continues to excite the admiration of the curious. The principal school of the art at the present day, is at Rome. The pictures in St Peter's are of mosaic of the modern school, copied from the works of Raphael, Dominichino, and other celebrated masters. In Mr Cadell's work, we find accounts of mosaic pictures of the different periods, which cannot fail to prove interesting to those who admire this species of imitation. But for these details we must refer to the work itself, confining ourselves to the extracts which explain the *Manufactory of Mosaic.*

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* The preceding experiments were made in January 1817, and signed by the President of the Physical Class of the Royal Society of Edinburgh on the 24th January 1817. A notice of them was read on the 21st April 1817; and the paper of which we have given an abstract, was read at the Royal Society of Edinburgh on the 30th April 1818, and at the Royal Society of London on the 12th November 1818. The experiments themselves were frequently shewn in the years 1817 and 1818 to several eminent foreigners.

† Extracted, by permission, from the author's learned and interesting book of Travels in Carniola and Italy, now in the press.

The manufactory of Mosaic pictures belonging to the Pope is in a large building to the south of St Peter's.

Enamels.—The building in which the establishment is situated is large, and contains a collection of enamels drawn into the form of sticks. These are arranged, according to their colours, in an extensive suite of rooms. The number of shades of colour is 17,000.

The enamel, consisting of glass mixed with metallic colouring matter, is heated for eight days in a glass-house, each colour in a separate pot. The melted enamel is taken out with an iron spoon, and poured on a polished marble placed horizontally; and another flat marble slab is laid upon the surface of the melted enamel, so that the enamel cools into the form of a round cake, of the thickness of $\frac{3}{10}$ths of an English inch.

In order to divide the cake into smaller pieces, the cake is placed on a sharp steel anvil, called Tagliulo, which has the edge uppermost, and a stroke of an edged hammer is given on the upper surface of the cake; the cake is thus divided into long parallelopipeds, or prisms, whose base is $\frac{3}{10}$ths of an inch square; and these parallelopipeds are again divided across their length by the tagliulo and hammer into pieces of the length of $\frac{8}{10}$ths of an inch, to be used in the mosaic pictures. Sometimes the cakes are made thicker, and the pieces larger.

For smaller pictures, the enamel, whilst fused, is drawn into long parallelopipeds, or quadrangular sticks; and these are divided across by the tagliulo and hammer, or by a file; sometimes also these pieces are divided by a saw without teeth, consisting of a copper blade and emery; and the pieces are sometimes polished on a horizontal wheel of lead with emery.

Gilded mosaic is formed by applying the gold leaf on the hot surface of a brown enamel, immediately after the enamel is taken from the furnace; the whole is put into the furnace again for a short time, and when it is taken out the gold is firmly fixed on the surface. In the gilded enamel used in mosaic at Rome, there is a thin coat of transparent glass over the gold.

Ancient Enamel.—The ancient Romans, besides the enamel for mosaic, made other works in enamel. Winklemann mentions ancient tiles of a kind of glass or enamel, for paving the floors of rooms; and he describes a small picture composed of filaments of enamel of different colours, agglutinated together by fusion, and each transverse section of this gave a picture like that at the extremity. The antique pastes, or artificial gems, are also products of art allied to enamel.

The Cement.—Anciently, the paste in which the pieces of mosaic are imbedded, called in Italy Stucco, was composed of one measure of quicklime quenched in water, and three measures of pounded marble; these were made into a mass with water and white of egg, and this was called Marmoratum; but this paste hardens too rapidly, so that it is hard before the workman has time to insert the pieces, and it is injured by damp more readily than the cement made with oil.

The paste now used is composed of one measure of quenched quicklime, and three measures of powdered Travertine stone; these are mixed with linseed oil, and are stirred and worked up every day with a trowel. The mass is at first level on the surface, but afterwards swells up. Each day some oil is added, to prevent the mass from becoming dry and untractable. The mass is ready a shorter time in warm weather than in cold; in summer the mass is at its perfection in twenty days; this is known from its ceasing to swell, the water that was in the lime having evaporated; the mass is then uniform throughout, like an ointment. In winter, and when the air is moist, it requires a month to bring the paste to perfection.

The wall to which the mosaic is to be applied, must have the lime taken off its surface; then furrows an inch deep are formed on the wall, to fix the cement.

For the same purpose large-headed nails are driven in, and wire is stretched from one nail to another. After this, the wall thus prepared, is painted over with linseed oil. Then the cement is laid on to the extent of a surface of as many palms as can be executed before the cement dries. The plasticity and softness of the cement lasts about twenty days; after that the oil exudes, and the lime and Travertine become a hard mass. The cement made with linseed oil is yellow; that made with white of egg is white, and the white cement is considered to be a character for distinguishing the old mosaic from the modern; but some of the modern is also made with white cement.

Account of Antique Marbles, Alabasters, Granites, &c. at Rome.

The many large columns of foreign marble and granite at Rome are amongst the remarkable remains of ancient magnificence, and vestiges of the seat of the most powerful empire that ever existed in Europe. Ravenna, which was the residence of Valentinian and Theodoric, also possesses some. At Venice there are some columns from the Levant. In the cathedral of Pisa there are columns of granite, and in some other places of Italy there are antique columns of foreign marble. But it is at Rome that by far the greatest quantity of marble columns are seen; many of them are employed in forming the colonnades of the naves of the churches, and, in that situation, present a beautiful view, which is not to be seen in any other city. The church of St Paul on the Via Ostiensis is the most magnificent in respect to the number and magnitude of the marble columns which separate the five porticos or naves.

The number, magnitude, and variety of the ancient columns and marbles is admirable at this day, after they have been exposed to the action of time for 1800 years, and the Roman authors speak of the sumptuous magnificence of these objects when recently brought from the quarries.

The word Marble was applied anciently to stones susceptible of polish, and distinguished by the beauty of their colours. The word is now usually confined to denote stones composed of carbonate of lime, of an agreeable colour, and taking a good polish.

There are no rocks of marble in the country near Rome. The Romans, therefore, in the time of their power, had recourse to the marble quarries of Carrara and of foreign countries, and chiefly to those in the eastern part of the Mediterranean, in order to adorn their buildings. Pliny mentions, that the first marble columns were brought to Rome 50 years before the first consulship of Augustus, and the importation continued for about 200 years, as long as the city was in a flourishing state.

Columns from Mount Hymettus.—It was only 50 years before the first consulship of Augustus that the first marble columns were brought to Rome by Crassus the orator, and he first employed marble columns in a private building. These columns were from Mount Hymettus, near Athens. He was reproached by the public opinion for this unusual magnificence.

Pentelican Marble.—Many of the ancient statues at Rome, according to the judgment of Visconti and other antiquaries, are of the white marble from Mount Penteles, near Athens. It is called, at Rome, Cipolla, or Statuary Cipollino, by reason of the greenish veins that occur in it. Of the statues formed of this marble are the Torso of the Belvedere and the Muses of the Vatican. The Parthenon and other ancient buildings at Athens are of Pentelican marble.

Parian Marble.—Other antique Greek and Roman statues are of the marble of the island of Paros, as the recumbent Ariadne, called the Cleopatra of the Belvedere; the Mercury, called the Antinous of the Belvedere; the Diana and Stag of the Louvre. The Venus de' Medici is of Parian marble, of a smaller grain than the ordinary Parian; the Venus of the Capitol is of very beautiful and translucid Parian.

Carrara Marble.—Others are of marble from Carrara, anciently called Marble of Luni, as the statue of Antinous of the Capitol.

The marble of Hymettus and the Pentelican are mentioned by Strabo and Pausanias.

The marble of which the Apollo of the Belvedere is formed is considered, by the marble-cutters at Rome, to be a Greek marble, though different from the Greek marble of which many other ancient statues are formed.

Pliny wrote 166 years after the first importation of marble, and remarks the rapid progress that had taken place in that period, from a simple and unadorned way of life to magnificence and extravagant expense. In the reign of Diocletian, 240 years after the beginning of the importation of foreign marble into Rome, that importation had diminished considerably, for it appears that columns, taken from more ancient buildings, were employed in constructing the Baths of Diocletian. But the largest of the two obelisks of the Circus Maximus was brought to Rome 30 years after Diocletian. Its removal from Egypt was begun by Constantine, and it was brought to Rome by the son of Constantine. For removing this, the largest wrought stone that has been moved in Europe, there existed sufficient mechanical skill at that period, although the arts connected with design had declined very considerably.

Scaurus, the stepson of Sylla, imported such a quantity of magnificent columns into Rome, and employed them so profusely in buildings, that they were not exceeded by the extravagant fabrics which Nero afterwards erected.

Marble of Carystus in Eubœa.—Soon after the time of Scaurus, Mamurra adorned his mansion with marble from Luni near Carrara, and from Carystus, now called Karesto, in Negropont. He was the first who encrusted walls with thin slabs of marble. The quarries of the Carystian columns are mentioned by Strabo, who speaks of asbestos found in the same place, and woven into cloth.

Black Marble.—In the year 680 of Rome, Lucullus employed a black marble, brought from an island in the Nile, and called Marmor Luculleum from his predilection to it.

Synnadic or Phrygian Marble.—The marbles of Synnados in Phrygia, the cipollino of the moderns, is spoken of by Strabo and Statius. This cipollino is a primitive and shistose marble, with particles of mica and green stripes, and is called Cipollino, from the resemblance it bears to a leek (cipolla) by its colour and scales.

Strabo mentions the quarries of white marble in *Paros*, in *Proconnesus* near Paros, and at *Mylassa* in Caria. He mentions quarries of variegated marble on the island of *Scyros*, east of Eubœa, on the small island of *Deucalion*, near Larissa in the Gulf of Salonica, and at *Hierapolis*, near Laodicea. From all these three, as well as from Carystus and Synnados, large columns were sent to Rome.

Marble of Rhodes.—Pliny mentions a marble with yellow veins got at Rhodes; to this marble he compares the stone called Lysimachus.

The greatest number of the large antique Roman columns are of cipollino, of red Egyptian granite, and of the four kinds of marble known at Rome by the names of Marmo Greco, Giallo Antico, Pavonazzetto, and Porta Santa.

Marmo Greco.—Marmo Greco is a shistose and primitive marble, of a bluish white, containing mica.

Giallo Antico.—Ancient yellow marble is, in some degree, translucid. The modern yellow Siena marble is opaque.

Pavonnazzetto has purple veins.

Porta Santa has red veins.

The *Breccia Africana*, which has dark-coloured blotches and veins, is somewhat less frequent.

Lacedemonian Marble.—The Lacedemonian marble mentioned by Statius and by Lucian, is supposed to be the marble now called Verde Antico. But, according to Visconti, the Verde Antico was imported from Thessalonica.

There are columns of Verde Antico in the Lateran, but there are no columns of this marble of so large a size as the columns of granite, cipollino, marmo Greco, and Giallo Antico.

Rosso Antico.—The ancient red marble, *rosso antico*, of an uniform brick-red, occurs in the two marble bathing-chairs, and in some busts and statues, but not in large columns.

Alabaster.—Of alabaster, or carbonate of lime in a stalactitical form, and translucid when cut into slabs of moderate thickness, there is an Egyptian statue at Rome; and two columns of this substance, about twelve feet high, were formerly in the vestibule of the Vatican library. This stone is called Alabastro fiorito, from the flowery form of its veins. The white alabaster, of which the small statues are made at Florence, is a different stone, being composed of sulphate of lime. The Derbyshire alabaster, of which there are inlaid columns in the hall at Keddlestone, is also sulphate of lime, but not of so pure a white as the Florentine.

Many other kinds of antique marbles, which occur more rarely than those above mentioned, are met with in the ruins and in the collections of marbles sold by the marble-cutters at Rome.

Numidian.—Lepidus, in the year 676 of Rome, first employed Numidian marble. Numidian marble is mentioned by Statius, Juvenal, and Seneca. Some commentators consider the Numidian marble to be red porphyry.

Seneca speaks of the *marble of Alexandria*; of the *Thasian* from the island of Thasos, which is situated north of Lemnos in the Ægean Sea; of *Egyptian columns*, which, perhaps, are granite; and of *African columns.*

Some of the above named marbles are mentioned by Statius, and also the *white marble of Tyre and of Sydon*, green marble *from the Eurotas* in Laconia, and *Lybian.* Some of the above kinds and others are also mentioned by Juvenal, Martial, Vopiscus, and Julius Capitolinus.

Egyptian Granite.—The columns of the portico of the Pantheon, the Ionic columns of the Temple of Concord in the Forum Romanum, and some others at Rome, are of large-grained red Egyptian granite, as are the obelisks, the largest wrought stones that exist in Europe. This red Egyptian granite, was called by the ancients Pyrrhopoikilon, on account of its variegated and red colour, and Syenite, because it was got in the quarries of Syena, in Upper Egypt. Pococke describes the quarries of granite which he visited at Syene. Some other kinds of granite from the east occur amongst the remains of ancient art at Rome, but not so frequently as the red Egyptian granite. The Roman marble-cutters saw blocks of antique granite by means of an iron blade and emery, as calcareous marble is sawed by an iron blade and siliceous sand. The hardness of granite renders the operation of sawing it very tedious.

Elba Granite.—There are some columns of Æthalian, or Elba granite, at Rome and Pisa. It is small-grained, and called, at Rome, Granitello.

Syenite of Mineralogists.—The syenite of the two lions, at the ascent to the Capitol, differs from the granite of the obelisks, and is like the stone of which the Egyptian colossal head, now (1818) in the British Museum is formed.

Basalt.—There are several ancient Egyptian sphinxes, and other figures, and labra balnearia, or bathing troughs, of a dull greenish basalt. Basalt is characterized by Pliny as resembling iron in hardness and colour; it more especially resembles cast iron. Strabo mentions a quarry of millstones which were, perhaps, of basalt, at the Black Promontory in Ionia.

Touchstone.—Pietra di Paragone, black touchstone, occurs in slabs and figures.

Porphyry.—The columns of porphyry at Rome are not nearly of so large a size as the large columns of granite. The urn of Constanza and the urn of Helena is each composed of a very large block of porphyry; and the great tazza or saucer-shaped reservoir in the rotonda of the Museo Pio-Clementino is of one great piece of porphyry. Pliny says that sculptors began to work in porphyry only in the reign of Claudius. Vopiscus mentions porphyry. The room in which the princes of the Greek empire were born was incrusted with porphyry, and the princes born in this room were called Porphyrogeneti. The name Porphyry, or purple, applied to this stone, was taken from the ancient purple dye, made of the shell-fish called Porphyrios, which was got near Tyre. It is, therefore, supposed that the ancient dye was of the dull red colour, which this stone exhibits. A small grained greenish porphyry is sometimes found, but much more rarely than the red porphyry, amongst the remains of ancient art at Rome; it is quite different from the antique green serpentine.

Antique Serpentine.—The green antique serpentine, which occurs in pavement of churches at Rome, is one of that class of stones called porphyry by the mineralogists.

Verde di Corsica.—In the Vatican there is a vase, which is probably antique, formed of the rock compounded of jade and schillerspar. This rock occurs near the magnesian serpentine in Tuscany and in Corsica.

Egyptian Breccia.—The Egyptian Breccia, which occurs in some monuments at Rome, is a conglomerate, composed of hard siliceous stones.

ART. XXVII.—*Abstract of Experiments on the Specific Gravity, Temperature, and Saline Contents of Sea-Water, &c.* By ALEXANDER MARCET, M. D. F. R. S., &c*.

THE very interesting paper of which we propose at present to give a brief analysis, is the production of an individual no less celebrated by his talents as a chemist and a physician, than by those better qualities, without which the loftiest attainments lose their splendour and their influence. During the last twenty years, a period during which England has contributed more than her usual contingent to the advancement of science, Dr Marcet's exertions have frequently held an honourable and conspicuous place; and we regret to think, that England is so soon to lose the benefit of his co-operation, as well as the influence of his example.

Dr Marcet's attention was directed at an early period to the analysis of water, and when the late celebrated Mr Tennant received from Sir Joseph Banks, some phials of the water of the Dead Sea and of the River Jordan, brought home by

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* See *Phil. Trans.* 1819, part ii. p. 161.

Mr Gordon of Clunie, he entrusted them to Dr Marcet, whom he knew to have been engaged in similar researches [*]. These eminent chemists embraced every opportunity of collecting sea-water from different parts of the world; and though the melancholy death of Mr Tennant interrupted for a considerable time the researches of his friend, he was induced to resume his labours after the return of the Arctic Expedition, which furnished him with numerous specimens of water from the Polar Seas.

Having procured above seventy different kinds of sea-water from different parts of the world, a great number of which were raised by an ingenious apparatus, invented by himself, Dr Marcet began his investigation of their physical properties, and their chemical composition.

The specific gravities were measured in the usual manner, by comparison with equal bulks of distilled water of the same temperature. As the results would occupy too much room, we have arranged them in the following table in groups, and given the extremes, as well as the mean, of the different results.

Places where the Water was obtained.	Number of Specimens.	Intervals of Latitude.	Intervals of Longitude.	Extremes of Specific Gravity.	Mean of all the Results.
Arctic Ocean,	12.	66° 50′ to 80 29	11° 15′ E. to 76 46 W.	1.02555 to 1.02727	1.02664
Northern Hemisphere,	15.	3 28 63 49	89 0 E. 55 38 W.	1.02648 1.0309	1.02829
Equator, -	4.	0 0	92 0 E. 25 30 W.	1.02692 1.02825	1.02777
Southern Hemisphere,	10.	8 30 35 33	73 0 E. 56 0 W.	1.02545 1.03209	1.02882
Yellow Sea,	1.	35 0 N.	——	1.02291	——
Mediterranean,	3.	36 0 N.	5 0 W.	1.0273 1.0305	1.0293
Sea of Marmora,	4.	40 5 N. 41 0 N.	26 12 E. 29 0 E.	1.01328 1.02819	1.01915
Black Sea,	2.	——	——	1.01414 1.01422	1.01418
White Sea,	2.	65 15 N.	39 19 E.	1.01894 1.01909	1.01901
Baltic, -	3.	56 0 N. 57 39 N.	15 0 E. 12 40 E.	1.0049[†] 1.02593	1.01523
Ice-sea waters,	6.	75 40 80 28	13 40 E. 65 32 W.	1.00000 1.00235	1.00057
Lake of Ourmia,	1.	——	——	1.16507	——

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[*] See *Phil. Trans.* 1807, part ii. 296.

[†] From Carlsham Harbour.

From the preceding facts Dr Marcet concludes,

1. That the Southern Ocean contains more salt than the Northern Ocean, in the ratio of 1.02919 to 1.02757.

2. That the mean specific gravity of sea-water near the Equator is 1.02777, intermediate between that of the Northern and Southern Hemispheres.

3. That there is no notable difference in sea-water under different meridians.

4. That there is no satisfactory evidence, that the sea at great depths is more salt than at the surface *.

5. That the sea, in general, contains more salt where it is deepest, and most remote from land, and that its saltness is always diminished in the vicinity of large masses of ice.

6. That small inland seas, though communicating with the ocean, are much less salt than the open ocean.

7. The Mediterranean contains rather larger proportions of salt than the ocean.

The singularity of this last result has been explained, upon the supposition that the Mediterranean is not supplied by the rivers which flow into it, with a quantity of fresh water sufficient to replace what it loses by evaporation under a burning sun, aided by a powerful radiation from the African shores, and the parching winds blowing from the adjacent desarts. Philosophers have, therefore, attempted to explain why this sea does not gradually increase in saltness, and indeed be ultimately converted into saturated brine. This has been ascribed to an under current of water, salter than the ocean, which runs out at the Straits of Gibraltar, and unloads its waters of their excess of salt. This idea of a submarine current is countenanced by the fact, communicated to Dr Marcet by Dr Macmichael, on the authority of the British Consul at Valentia, that some years

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* A similar conclusion was deduced by Mr Scoresby, who obtained the following results. See his *Account of the Arctic Regions.*

	Depth in Feet.	Spec. Grav.		Depth in Feet.	Spec. Grav.		Depth in Feet.	Spec. Grav.
Lat. 76° 16′	Surface	1.0261	Lat. 76° 34′	Surface	1.0265	Lat. 77° 40′	Surface	1.0267
	738	1.0270		120	1.0264		300	1.0265
	1380	1.0269		240	1.0266		660	1.0262
				360	1.0268			
				600	1.0267			

ago, a vessel was lost at Ceuta, on the African coast, and its wreck afterwards thrown up at Tariffa, on the European shore, fully two miles west of Ceuta *.

The results obtained by Dr Marcet from twelve specimens of water from the Arctic Seas, agree wonderfully with those previously obtained by Dr Fyfe, from sixteen specimens, and published in the 1st Number of this *Journal,* the intervals of latitude and longitude being nearly the same, and also with those of Mr Scoresby, published in his work on the Arctic Regions.

	Number of Specimens.	Intervals of Latitude.	Intervals of Longitude.	Specific Gravity.
Dr Fyfe's result,	16.	61° 52′ N. 78 25 N.	10° 20′ E. 65 32 W.	1.02697
Dr Marcet's result,	12.	66 50 N, 80 29 N.	11 15 E. 76 46 W.	1.02664
Mr Scoresby's result,	14.	76 16 N. 80 0 N.	90 0 E. 0 10 W.	1,02653

Dr Marcet next proceeds to give an account of the general results respecting the temperature of the Polar Seas, as obtained by the officers of the late expedition to those regions; but it is a duty which we owe to Mr Scoresby to state, that he has completely anticipated them in these observations.

In Baffin's Bay, the Mediterranean Sea, and the Tropical Seas, *the temperature of the sea diminishes* with the depth, according to the observations of Phipps, Ross, Parry, Sabine, Saussure, Ellis and Peron; but it is a remarkable fact, that in the Arctic or Greenland Seas, *the temperature of the sea increases* with the depth. This singular result was first obtained by Mr Scoresby, in a series of well conducted experiments †, and has been confirmed by the later observations of Lieutenants Franklin, Beechy, and Mr Fisher.

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* A similar fact is stated by Dr Hudson: " In 1712, M. de L'Aigle of the Phœnix of Marseilles, giving chace near Ceuta Point to a Dutch ship, came up with her in the middle of the Gut between Tariffa and Tangier, and there gave her one broadside, which sunk her. A few days after, the sunk ship, with her cargo of brandy and oil, arose on the shore near Tangier, at least four leagues to the west of the place where she sunk, and directly against the strength of the current; which has persuaded many men that there is a *recurrency in the deep water in the middle of the Gut that sets outward to the grand ocean, which this accident very much demonstrates.*"—*Phil. Trans.* 1724, vol. xxxiii. p. 192.

† See Scoresby's *Account of the Arctic Regions*, vol. i. p. 187.

The following is an Abstract of Mr Scoresby's results.

Lat.	Long.	Depth in Feet.	Temperature.	Temp. of Air.
76° 16′	9° 0′ E.	Surface	28°.8	12°
—	—	300	31.8	
—	—	738	33.8	
76 16	10 50	Surface	28.3	16
—	—	738	30.0	
76 34	10 0	Surface	30.0	25
—	—	600	34.7	
77 15	8 10	Surface	29.3	16
—	—	600	30.0	
77 40	5 40	Surface	29.0	34
—	—	2400	30.0	
79 4	5 38	Surface	29.0	38
—	—	4380	37.0	
80 0	5 0	Surface	29.7	40
—	—	720	36.3	
78 2	0 10 W.	Surface	32.0	36
—	—	4566	38.0	

The following are some of the results obtained by Lieutenant Beechy on board the Trent.

Lat.	Long.	Depth in Fath.	Temp. at Bottom.	Temp. of Surface.
79° 44′	9° 34′ E.	15	34.0°	33°.0
79 58	11 14	30	31.0	30.0
79 52	9 57	60	34.0	32.0
80 23	9 50	120	36.0	30.3
80 21	11 11	140	36.5	30.5
80 27	11 5	200	35.5	32.5
80 23	11 3	237	27.0	32.0
76 48	12 26	700	43.0	33.0

The following are some of Mr Fisher's results, obtained on board the Dorothea.

Latitude.	Longitude.	Depth in Fath.	Temp. at Bottom.	Temp. of Surface.
Between 79° 50′ and 80 14	11° 30′ E.	40	35°.5	31°.8
		60	36.0	32.0
		100	36.3	32.0
		124	36.7	33.5
		140	36.5	32.0
		188	42.5	33.0
		304	39.0	31.0

The greatest difference found by Lieutenant Parry was 6°, at a depth of 246 fathoms; and the greatest obtained by Captain Sabine was $7\frac{1}{2}$°, at a depth of 680 fathoms.

By cooling sea-water with freezing mixtures, and ascertaining its specific gravity at each degree of temperature, as it approached congelation, Dr Marcet found, that the law of maximum density at 40° did not prevail in the case of sea-water; but, on the contrary, sea-water gradually increased in weight down to the freezing point. This able chemist confirmed this result by means of an ingenious instrument, with which he measured the bulk of the water under various temperatures. The water was always found to contract in bulk down to 22° of Fahrenheit, when the water appeared to expand a little, and continued to do so till its temperature descended to between 19° and 18°, when the fluid suddenly expanded to a very considerable degree, shooting up with great rapidity, and forcing itself out of the open end of the tube. At the same moment the thermometer rises to 28°, and remains at that point. The liquid is now found frozen, and in a few minutes the maximum of expansion is obtained.

Dr Marcet next proceeds to ascertain the saline contents of the different seas; and in this investigation he employed a method which he had long ago used and explained in his analysis of the Dead Sea, published in the Phil. Trans. for 1807. "It is satisfactory to observe," says Dr Marcet, "that Dr Murray adopted, several years afterwards, a mode of proceeding precisely similar, and indeed, that he proposed, in a subsequent paper, (*Edin. Trans.* 1816, Vol. viii.) a general formula for the analysis of mineral waters, in which this method is pointed out as likely to lead to the most accurate results. And this coincidence is the more remarkable, as it would appear from Dr Murray not mentioning my labours, that they had not at that time come to his knowledge." All the results which Dr Marcet obtained by this mode of investigation prove, that sea-water contains the same ingredients all over the world, and that these bear very nearly the same proportion to each other, differing only in the total amount of their saline contents.

The following table contains all the results obtained by Dr Marcet.

Synthetic View of the Results obtained from the Analysis of different Seas; the Quantity of Water operated upon being supposed to be 500 Grains.

Description of the Specimens.	Specific Gravity.	Residue of Evaporation of 500 grs. water	Muriate of Silver.	Sulphate of Barytes.	Oxalate of Lime.	Phosphate of Magnesia.	Total of Precipitates from 500 grs. water.	OBSERVATIONS.
Arctic Ocean. Spec. 1.	1027.27	Grains. 19.5	Grs. 39.7	Grs. 3.3	Grs. 0.85	Grs. 2.7	Grains. 46.55	The quantity actually operated upon was 500 grs.
Arctic Ocean. Spec. 12.	1019.7	14.15	27.9	2.4	0.7	1.8	32.8	From surface. Quantity operated upon 500 grs.
Arctic Ocean. Spec. 67.	1002.35	1.75	3.2	0.1	0.05	0.03	3.37	Sea ice water; coast of Spitzbergen. Opd. on 500 grs.
Arctic Ocean. Spec. 14.	1027.05	19.3	38.9	3.25	0.95	2.9	46.	From a depth. Operated on 500 grains.
Equator. Spec. 35.	1027.85	19.6	40.3	3.7	0.9	3.1	48.	From surface. Operated on 500 grains.
S. Atlantic. Spec. 41.	1028.19	20.6	40.4	3.75	1.0	3.2	48.3	Operated on 250 grains.
White Sea. Sp. 58. & 59.	1022.55	16.1	31.8	3.0	0.6	2.2	37.6	Operated on 500 grs., but evaporated only 250 grs.
Black Sea. Sp. 56. & 57.	1014.22	10.8	19.6	1.95	0.55	1.5	23.6	Operated on 500 grs. for the earths; on 250 for mur. of silver and evap. of water.
Baltic. Spec. 60.	1004.9	3.3	7.	0.7	0.2	0.6	8.5	Operated on 250 grs. The precipitates slightly tinged by veget. or anim. matter.
Sea of Marmora. Surface. Spec. 53.	1020.28	14.11	28.4	2.65	0.4	2.35	33.8	Entrance of Hellespont. Surface. Opd. on 500 grs. except for mur. of silver.
Sea of Marmora. Bottom. Spec. 52.	1028.19	21.	40.4	3.55	0.9	3.2	48.05	From bottom. Carb. of lime deposited during evap. but none from the water at surface. Operated on 500 grs.
Middle of N. Atlantic. Spec. 27.	1028.86	21.3	42.	3.85	0.8	2.7	49.35	Operated on 250 grs. for evap. of water and mur. of silver. 500 for other salts.
Yellow Sea. Spec. 48.	1022.91	16.1	32.9	1.35	0.75	2.2	37.2	During concentration deposited carbon. of lime. The water was yellowish, and had a strong hepatic smell. Operated on 500 grs.
Mediterranean. Spec. 51.	1027.3	97.7	38.5	3.6	0.8	3.0	45.9	From Marseilles, and rather weak, from vicinity of rivers. Opd. on 100 grs. for evap. and mur. of silver; and 250 for other salts.
Dead Sea.	1211.	192.5	326.4	0.5	9.78	55.5	584.68	Phil. Trans. 1807.
Lake Ourmia, in Persia.	1165.07	111.5	237.5	66.0	0.	10.5	425.5	Spec. brought by Brown. Operated on 100 & 50 grs.

General Observations.

In the above experiments, the residues were dried as follows, viz. The residue obtained from the water by evaporation, was thoroughly dried at a boiling heat in a water-bath, till it entirely ceased to lose weight. The muriate of silver was heated to incipient fusion; the sulphate of barytes and oxalate of lime were dried at a boiling heat; and the ammoniaco-phosphate of magnesia, was heated to redness. No filters were used. The precipitates were washed, dried, and weighed, in the same glass capsules in which they were formed, with the exception of the magnesian salt, which was heated to redness by means of the blowpipe, in a very thin and small platina crucible.

ART. XXVIII.—*On the Formation of Sugar from the Sawings of Wood, Old Linen and Paper.* By M. BRACONNOT.

OUR chemical readers are no doubt well aware of the interesting experiments of M. Kirchoff, a Russian chemist, by which he discovered that *starch* may be converted into *sugar*, possessing all the properties of sugar from grapes, by mixing it with about four times its weight of water, and about one hundred part of its weight of sulphuric acid *. This discovery was confirmed by M. Theodore de Saussure, who ascertained that 100 parts of starch became 110.14 parts when turned into sugar.

The same subject has been successfully resumed by M. Braconnot, who has discovered the important fact, that a sugar similar to that of grapes may be obtained by means of sulphuric acid, from the sawings of wood, and from old linen.

In this operation, a certain quantity of these substances are treated with sulphuric acid, concentrated by cold. The mass appears to be carbonised, but this appearance arises from a stratum of black powder which covers it; and which, when removed by washing, is converted into a true gum, resembling in many respects gum arabic, and likely to be of some use in the arts. This gum is separated from the sulphuric acid in excess by means of carbonate of lime, and it remains in the liquor. By afterwards treating this gum with sulphuric acid diluted with water, at 30° or 40° and in ebullition, *it is converted into true sugar of grapes, the quantity of which is greater than that of the sawings of wood or the linen employed.* In addition to this sugar, which forms almost the whole of the mass, M. Braconnot obtained another substance, which he called the *vegeto-sulphuric acid.* It is composed of sulphur, carbon, hydrogen, and oxygen; or of a vegetable matter, and the elements of sulphuric acid. It is separated from the mass by rectified alcohol, which dissolves it, and it is freed, from the small quantity of saccharine matter which it may contain, by agitating it, after it has been evaporated into a syrup with ether. This acid, when pure, is deliquescent, uncrystallisable, and extremely acid. It is decomposed and becomes black, when put into a capsule plunged in a sand-bath, even at a temperature below boiling-water. It produces no change in metallic solutions; does not precipitate nitrate of barytes, nor nitrate of lead; effervesces strongly with carbonates; and it is capable of dissolving all the metallic oxides, with which it forms deliquescent salts, insoluble with rectified alcohol. When subjected to heat, these saline and neutral combinations are decomposed, and emit sulphurous acid, and leave sulphates and charcoal. This new acid dissolves iron and zinc, liberating abundance of oxygen gas. It even dissolves sulphate of lead to a certain degree; and it forms, with oxide of lead and barytes, very soluble salts, which have a gummy appearance.

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* Kirchoff also found that some other acids had the same effect. See *Journal de Physique*, tom. lxxiv.

M. Thenard, from whose report the preceding facts are taken, announces, that M. Pouillet has been occupied for six months in experiments analogous to those of M. Braconnot; and that he has obtained *sugar*, by treating *Paper* with diluted sulphuric acid.

Art. XXIX.—A *very Concise, yet strictly Accurate Method, for finding the Interest of any given Sum, at any given Rate, for any given Number of Days.* By Henry Goodwyn, Esq. Blackheath, Kent. In a Letter to Dr Brewster.

Sir,

I have experienced, for many years, the utility of the Interest Table which I have now the honour of presenting to you. Several gentlemen, of well known mathematical ability in this neighbourhood, have spoken favourably of it, not only as possessing the properties above ascribed to it, but also as furnishing a fair example of the great benefit which may be derived from introducing the circles or circulating digits, distinctly from the prefixed digits, or finite part of the decimals, whenever mixed and circulating decimals are to be applied in any extent to practical purposes.

It does not appear to me that any description of the different parts of the Table is necessary, as the titles at the heads of the columns seem sufficient for pointing out what they severally are. As to the two Tablets, however, which contain the circulating digits of the decimals, it may be observed, that each of the *nine* circles in the tablet for £5 *per cent.* is the same; that is consists of the same digits with one or other of those in the tablet for £1 *per cent.* In fact, it is this last-mentioned tablet which completes the Table; and they alone, if every thing about £5 *per cent.* were omitted, would be then, as they are now, of universal application. It is for its usefulness, then, as the *legal* and common rate of interest, that the tablet, &c. for £5 *per cent.* has been superadded.

That the nine circles are all which can exist in the present case, that is all that can possibly arise from the division of any given whole number less than 365 (the days in a year) by 365, admits of easy investigation and proof. But for this, as well as for a new mode of finding the circles themselves in all such instances, I would beg leave to refer to the second section of the Appendix to the "Centenary," and "Tabular Series."

I am, Sir, &c.

Henry Goodwyn.

AN INTEREST TABLE.

Prefixed Decimal Digits, at £1 *per Cent. per Annum.*					Indexes to Circulating Decimals.	Prefixed Decimal Digits, at £1 *per Cent. per Annum.*					Indexes to the Circulating Decimals.
·000	·002	·004	·006	·008		·001	·003	·005	·007	·009	
Days.						Days.					
0	73	146	219	292		37	110	183	256	329	*E h*
1	74	147	220	293	*A a*	38	111	184	257	330	*D g*
2	75	148	221	294	*B a*	39	112	185	258	331	*I f*
3	76	149	222	295	*C a*	40	113	186	259	332	*D b*
4	77	150	223	296	*D a*	41	114	187	260	333	*H g*
5	78	151	224	297	*E a*	42	115	188	261	334	*I d*
6	79	152	225	298	*F a*	43	116	189	262	335	*C f*
7	80	153	226	299	*C d*	44	117	190	263	336	*B h*
8	81	154	227	300	*C c*	45	118	191	264	337	*H h*
9	82	155	228	301	*G a*	46	119	192	265	338	*A g*
10	83	156	229	302	*A b*	47	120	193	266	339	*H b*
11	84	157	230	303	*E g*	48	121	194	267	340	*I c*
12	85	158	231	304	*H a*	49	122	195	268	341	*G g*
13	86	159	232	305	*F f*	50	123	196	269	342	*E b*
14	87	160	233	306	*F d*	51	124	197	270	343	*A d*
15	88	161	234	307	*D h*	52	125	198	271	344	*G h*
16	89	162	235	308	*F c*	53	126	199	272	345	*B f*
17	90	163	236	309	*G b*	54	127	200	273	346	*B c*
18	91	164	237	310	*I a*	55	128	201	274	347	*I e*
19	92	165	238	311	*B g*	56	129	202	275	348	*G f*
20	93	166	239	312	*B b*	57	130	203	276	349	*F g*
21	94	167	240	313	*G d*	58	131	204	277	350	*D d*
22	95	168	241	314	*A h*	59	132	205	278	351	*F h*
23	96	169	242	315	*E f*	60	133	206	279	352	*F b*
24	97	170	243	316	*G c*	61	134	207	280	353	*H e*
25	98	171	244	317	*I g*	62	135	208	281	354	*E c*
26	99	172	245	318	*H f*	63	136	209	282	355	*A f*
27	100	173	246	319	*A c*	64	137	210	283	356	*G e*
28	101	174	247	320	*H d*	65	138	211	284	357	*C g*
29	102	175	248	321	*B d*	66	139	212	285	358	*C h*
30	103	176	249	322	*C b*	67	140	213	286	359	*F e*
31	104	177	250	323	*I h*	68	141	214	287	360	*E e*
32	105	178	251	324	*H c*	69	142	215	288	361	*D e*
33	106	179	252	325	*D f*	70	143	216	289	362	*C e*
34	107	180	253	326	*I b*	71	144	217	290	363	*B e*
35	108	181	254	327	*D c*	72	145	218	291	364	*A e*
36	109	182	255	328	*E d*						
	·01. ·05.	is the Interest of £1 at	1 5	*per Cent.* for 1 Year, or						365	
Prefixed Decimal Digits at £5 *per Cent. per Annum.*											
·00	·01	·02	·03	·04		·00	·01	·02	·03	·04	

Circulating Digits of the Decimals,
AT
£ 1 *per Cent. per Annum.* £ 5 *per Cent. per Annum.*

	a	b	c	d	e	f	g	h		a	b	c	d	e	f	g	h
A	$\dot{0}$	2	7	3	9	7	2	$\dot{6}$	*A*	$\dot{0}$	1	3	6	9	8	6	$\dot{3}$
B	$\dot{0}$	5	4	7	9	4	5	$\dot{2}$	*B*	$\dot{0}$	2	7	3	9	7	2	$\dot{6}$
C	$\dot{0}$	8	2	1	9	1	7	$\dot{8}$	*C*	$\dot{0}$	4	1	0	9	5	8	$\dot{9}$
D	$\dot{1}$	0	9	5	8	9	0	$\dot{4}$	*D*	$\dot{0}$	5	4	7	9	4	5	$\dot{2}$
E	$\dot{1}$	3	6	9	8	6	3	$\dot{0}$	*E*	$\dot{0}$	6	8	4	9	3	1	$\dot{5}$
F	$\dot{1}$	6	4	3	8	3	5	$\dot{6}$	*F*	$\dot{0}$	8	2	1	9	1	7	$\dot{8}$
G	$\dot{2}$	4	6	5	7	5	3	$\dot{4}$	*G*	$\dot{1}$	2	3	2	8	7	6	$\dot{7}$
H	$\dot{3}$	2	8	7	6	7	1	$\dot{2}$	*H*	$\dot{1}$	6	4	3	8	3	5	$\dot{6}$
I	$\dot{4}$	9	3	1	5	0	6	$\dot{8}$	*I*	$\dot{2}$	4	6	5	7	5	3	$\dot{4}$

The method of using the Table, will be understood from the following

RULES AND EXAMPLES.

THE complete decimal of the interest on £ 1 for any given number of days less than a year, at the rate of £ $\left\{\begin{matrix}1\\5\end{matrix}\right\}$ *per cent. per annum*, may be found by inspection: thus,

Seek the given number of days, in one of the day columns; and take out the $\left\{\begin{matrix}\text{three}\\\text{two}\end{matrix}\right\}$ decimal digits which are placed directly $\left\{\begin{matrix}\text{over}\\\text{under}\end{matrix}\right\}$ that column in which the number of days is found. Observe the two letters that *follow* in the same horizontal line with the number for the days. At the angle of meeting of these two letters in the Tablets for the circulating digits of the decimals at £ $\left\{\begin{matrix}1\\5\end{matrix}\right\}$ *per cent. per annum*, is the first digit of that circle, which, when annexed to the $\left\{\begin{matrix}\text{three}\\\text{two}\end{matrix}\right\}$ decimal digits already found, will produce the complete decimal expression for the interest required.

Example.—Required the interest on £ 1, at £ $\left\{\begin{matrix}1\\5\end{matrix}\right\}$ *per cent. per annum*, for 155 days.

$\left\{\begin{matrix}\text{Over}\\\text{Under}\end{matrix}\right\}$ 155 days are the $\left\{\begin{matrix}\text{three}\\\text{two}\end{matrix}\right\}$ digits $\left\{\begin{matrix}\cdot 004\\\cdot 02\end{matrix}\right\}$. Against 155 days are the two letters *G a*, and at the angle of meeting of these two letters in the Tablets of Circulating Digits at £ $\left\{\begin{matrix}1\\5\end{matrix}\right\}$ *per cent.* is the figure $\left\{\begin{matrix}2\\1\end{matrix}\right\}$ of the circle $\left\{\begin{matrix}\dot{2}465753\dot{4}\\\dot{1}232876\dot{7}\end{matrix}\right\}$, which, being annexed to $\left\{\begin{matrix}\cdot 004\\\cdot 02\end{matrix}\right\}$, will be the answer. Thus, £ $\left\{\begin{matrix}\cdot 004\dot{2}465753\dot{4}\\\cdot 02\dot{1}232876\dot{7}\end{matrix}\right\}$, that is, £$\cdot 004\dot{2}465753\dot{4}$, at £1 *per cent.*; and £$\cdot 02\dot{1}232876\dot{7}$, at £ 5 *per ct.* is the Answer.

When the principal is greater or less than £ 1, or the rate greater or less than 1 *per cent.*, the interest is first to be found for the given number of days, as if for £ 1, at 1 *per cent.* This interest, multiplied by the given principal, or by the given rate, or by both, as the case may be, will give the answer required respectively. Thus,

Since £$\cdot 004\dot{2}465753\dot{4}$ is the interest of £ 1, at 1 *per cent.*, for 155 days;

$\cdot 004\dot{2}465753\dot{4}\times 400 = 1\cdot\dot{6}9863013\dot{6}$ will be the interest of £ 400 at the same rate and for the same time.

Also, $\cdot 004\dot{2}465753\dot{4}\times 5 = \cdot 02\dot{1}232876\dot{7}$ is the interest of £ 1 for 155 days, at £ 5 *per cent.* as found above from the Table.

And $\cdot 004\dot{2}465753\dot{4}\times 400\times 5 = 8\cdot\dot{4}931506\dot{8}$ shows the interest of £ 400 at £ 5 *per cent.* for 155 days.

The amount of any Annual Salary, for any given number of days, may also be readily found by the foregoing Table, as follows:—Having found in it the interest of £1, at 1 *per cent. per annum*, for the given number of days, multiply that interest by the annual salary, and remove the decimal point two places to the right: the product, so altered, is the answer.

Example.—Required the amount, for 155 days, of an annual salary of £20.

Since $\pounds{\cdot}004\dot{2}465753\dot{4}$ is the interest of £1 at 1 *per cent. per annum* for 155 days, and $\cdot004\dot{2}465753\dot{4}\times 20 = {\cdot}08\dot{4}931506\dot{8}$, &c. by removing the decimal point two places to the right, the product will become $8{\cdot}\dot{4}931506\dot{8}$, &c. the answer. And this answer is the same as that for the interest of £400 at £5 *per cent.* (= £20 *per annum*) for 155 days.

In practice, it will rarely, if ever, be requisite to take out more of the decimal digits than will be sufficient, when multiplied by the given principal, to produce *three*, or at the most *four*, decimal digits in the product; as that number will give the answer to the nearest farthing. So, in the first example, at $\pounds\left\{\begin{matrix}1\\5\end{matrix}\right\}$ *per cent.*, *seven*, or even *six*, digits will be quite sufficient. Thus, $\left\{\begin{matrix}\cdot004\dot{2}465\\ \cdot021\dot{2}325\end{matrix}\right\}\times 400 = \pounds\left\{\begin{matrix}1{\cdot}6986\\8{\cdot}4931\end{matrix}\right\}$ the answer.

It will, moreover, greatly expedite the whole process to be able mentally and instantaneously to convert the above $\left\{\begin{matrix}\cdot6986\\ \cdot4931\end{matrix}\right\}$, or any other decimals of a pound Sterling, into shillings, pence, and farthings; and the reverse: operations, of which the mode may easily be learned from almost every treatise on decimal arithmetic. In the above instance, $\left\{\begin{matrix}1{\cdot}6986\\8{\cdot}4931\end{matrix}\right\} = \pounds\left\{\begin{matrix}1:13:11\frac{1}{2}\\8:\ \ 9:10\frac{1}{4}\end{matrix}\right\}$. Results may thus be obtained, which, for ease and accuracy, can scarcely be produced from any of the voluminous Tables of Interest that have come under the Calculator's observation. An additional advantage may be gained by means of Contracted Multiplication in finding the products; as will be evident from a few examples.

Example I.

Required the Interest on £375 for 155 days at 5 *per cent. per annum*?

155 days, *per* Table, at £5 *per cent.*
$= {\cdot}02 + Ga =$ ·0212328 &c. which being multiplied by 375, or rather, when prepared for contract. mul. by 573

636984
148630
10616

will produce 7.96230 = £7:19:3 Ans.

Example II.

Required the Interest on £4287, 10s. for 359 days at £5 *per cent. per annum*?

359 days, *per* Table, at £5 *per cent.*
$= {\cdot}04 + Fe =$ ·0·4917808 &c. which being multiplied by £4287, 10s. = 4287·5, or rather by 5·7824

19671232
983562
393424
34425
2459

will produce 210·85102 = £210:17:0¼ Ans.

Example III.

Required the Interest on £1630, 10s. for 207 days at 3½ *per cent. per annum*?

207 days, *per* Table, at £1 *per cent.*
$= {\cdot}005 + He =$ ·00567123 multiplying by 3½ *per cent.* = 3·5, which, or rather by 5·3

1701369
283561

the result is ·01984930
£1630 10 = £1630·5, or rather when prepared for contracted multiplication, 5·0361

1984930
1190958
59548
992

will produce 32·36428 = £32:7:3½ Ans.

It is manifest from the above Examples, that the use of the Table is not confined to any particular Principal or fixed Rate of Interest. Nor, excepting in so far as regards *inspection*, is it limited to any determinate Number of Days; for, when the Interest of any given Sum, at any given Rate, has been found for ONE DAY, it is evident, that the interest of that same Sum, at the given Rate, for any given Number of Days, must be the Interest so found for ONE DAY multiplied into the given Number of Days.

ART. XXX.—*Account of a Meteorological Journal for* 1819, *kept at Kinfauns by the* Reverend ROBERT GORDON. In a Letter to Dr BREWSTER.

SIR,

TO render the following tables intelligible to your readers, it may perhaps be necessary to explain the plan of the journal from which they are taken. In that journal, the day is supposed to commence at 10 on the morning of one day, and to terminate at 10 on the morning of the next. At that hour, the self-registering thermometers are adjusted; and the highest and lowest points to which they had risen and sunk previous to that adjustment, are recorded as the extremes of the preceding twenty-four hours. The difference between these quantities is carried to another column, as the range of the thermometer during the same period. The last column under the head Thermometer, contains the mean temperature of water, conveyed in a pipe for several hundred yards under ground, at the medium depth of about three feet. This temperature is the result of three observations taken at equal intervals every month. The other columns under this head require no explanation.

From the want of a self-registering Barometer, my observations of that instrument are confined to its actual height at 10 morning and evening. The columns, therefore, that contain the range of the mercury, must be considered only as an approximation to the true quantity; but they serve to show the oscillations of the mercurial column, without the trouble of comparing two consecutive observations. The difference between the morning and evening observations of the same day is entered as the range during the day, and the difference between the observation in the evening and that of the following morning, is entered in another column as the range during the night.

The columns under the head Hygrometer, contain what I believe is not to be found in any other meteorological journal, and will therefore require a more particular explanation. Most of your readers are probably aware, that of the numerous instruments given to the world under the name of Hygrometers, there is not one that shows correctly either the absolute or relative humidity of the atmosphere. The greater part of them depend on the mechanical texture of animal or vegetable substances, and are subject, therefore, to such derangements, as must render their indications altogether unsatisfactory. The Differential Thermometer, applied to the purposes of hygrometry, is not liable to the objection now stated; but as its indications are modified by temperature, it does not directly convey any satisfactory information respecting the hygrometric state of the air. An accurate hygrometer, therefore, was still a desideratum in meteorology, till the publication of the article HYGROMETRY, in the *Edinburgh Encyclopædia*, where it has been supplied, not by the invention of a new instrument, but from contemporaneous observations of the thermometer and hygrometer, or simply of two thermometers, one of them having its bulb covered with moistened silk or paper. In that profound and ingenious treatise, the author * has given a formula from which may be deduced, in any given state of a wet and dry thermometer, the following interesting results.

1st, The point of deposition, or that temperature at which the air, if cooled down, would begin to deposit moisture.

2d, The absolute humidity of the atmosphere, or the quantity of moisture contained in a given portion of air. In the following tables this moisture is expressed in decimals of a grain Troy for every 100 cubic inches of the atmosphere.

3d, The relative humidity of the air, complete dryness being denoted by 0, and complete saturation by 100. This result expresses the quantity of moisture which the atmosphere contains, in hundredths of what would produce complete saturation, at the given temperature.

To facilitate the application of the formula, I have constructed from it a table, by which the above results may be found from simple inspection. It is hardly necessary to observe, that the whole is deduced from the depression of temperature, by evaporation from the moistened thermometer below that of the dry one.

I have only to observe farther, that the quantity of rain is ascertained by a gauge placed in an open situation, six feet above the surface of the ground, and the evaporation by a basin sheltered from the sun, and nearly in contact with the thermometers. The place of observation is on the Banks of the Tay, four miles below Perth, 185 feet above the level of the sea, and on the south side of a hill that rises to the height of about 400 feet above the river.

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* Adam Anderson, Esq. F. R. S. E. rector of the Academy, Perth.

Meteorological Observations, Latitude 56° 25′ N.

1819.	THERMOMETER.							
Months.	Mean of greatest heat.	Mean of greatest cold.	Mean at 10 M.	Mean at 10 E.	Mean of Extremes.	Mean of 10 and 10.	Mean range in 24 hours.	Mean Temp. Spring Water.
Jan.	42.5	33.3	38.2	36.8	37.9	37.5	9.2	41.1
Feb.	41.7	31.9	36.9	35.6	36.8	36.2	9.8	36.3
March	48.3	36.7	43.8	40.7	42.5	42.2	11.6	40.9
April	51.0	37.9	46.5	42.3	44.5	44.4	13.1	44.3
May	57.4	43.3	52.4	46.6	50.3	49.5	14.1	48.0
June	62.6	45.8	57.4	50.3	54.2	53.9	16.8	51.7
July	67.0	51.9	61.7	55.5	59.4	58.6	15.1	56.4
Aug.	69.9	55.4	64.6	59.2	62.6	61.9	14.5	60.7
Sept.	60.2	47.6	55.8	52.5	53.9	54.1	12.6	56.9
Oct.	51.9	40.5	47.6	45.2	46.2	46.4	11.4	52.2
Nov.	41.9	31.6	37.3	35.6	36.8	36.5	10.3	43.0
Dec.	37.0	27.4	33.6	31.9	32.2	32.8	9.6	40.3
Aver.	52.6	40.3	48.0	44.3	46.4	46.2	12.3	47.9
1818.	53.2	41.2	48.8	45.1	47.2	46.9	12.1	47.4

BAROMETER.								
Mn. 10 M.		Mn. 10 E.		Mn. of both.		Mean range in the Day.	Mean range in the Night.	Mean range in 24 Hours.
Temp.	Pressure.	Temp.	Pressure.	Temp.	Pressure.			
44	29.422	44	29.390	44	29.406	.191	.197	.388
43	29.363	42	29.371	43	29.367	.173	.171	.344
47	29.669	47	29.689	47	29.679	.123	.121	.244
50	29.666	50	29.657	50	29.661	.084	.073	.157
54	29.787	54	29.787	54	29.787	.082	.047	.129
59	29.662	59	29.675	59	29.668	.095	.088	.183
63	29.867	63	29.890	63	29.879	.077	.070	.147
67	29.911	67	29.899	67	29.905	.070	.058	.128
59	29.753	59	29.775	59	29.764	.110	.079	.189
53	29.704	53	29.739	53	29.721	.093	.105	.198
44	29.594	44	29.594	44	29.594	.144	.157	.301
40	29.566	40	29.583	40	29.574	.122	.122	.244
52	29.664	52	29.671	52	29.667	.113	.108	.221
52	29.652	52	29.655	52	29.653	.113	.110	.223

1819.	Anderson's Hygrometer.									Rain.	Evap.
	Point of Deposition.			Moist. in 100 cubic in. of Air.			Relative Humidity.				
Months.	Mean 10 M.	Mean 10 E.	Mean of both.	Mean 10 M.	Mean 10 E.	Mean of both.	Mean 10 M.	Mean 10 E.	Mean of both.	Amount.	Amount.
Jan.	33.8	32.7	33.3	.146	.139	.142	86.4	87.1	86.7	3.372	.975
Feb.	31.7	30.4	31.1	.136	.130	.133	84.5	84.1	84.3	2.191	.750
March	34.3	33.4	33.8	.149	.144	.146	73.7	78.7	76.2	.758	1.800
April	36.0	35.7	35.9	.156	.155	.156	72.0	81.2	76.6	4.175	1.840
May	39.3	40.7	40.0	.180	.182	.181	67.6	82.9	75.3	1.238	2.650
June	45.8	44.3	45.0	.216	.204	.210	69.9	82.6	76.3	2.617	2.800
July	51.9	50.2	51.1	.264	.248	.256	74.0	84.6	79.3	1.256	2.735
Aug.	57.3	55.4	56.4	.310	.292	.301	79.8	88.5	84.1	1.308	2.366
Sept.	46.9	46.6	46.8	.224	.224	.224	75.9	82.9	76.4	1.523	1.950
Oct.	39.5	38.4	38.9	.187	.180	.183	77.7	80.2	78.9	4.015	1.430
Nov.	30.9	30.8	30.9	.132	.132	.132	81.3	85.5	83.4	1.518	.825
Dec.	29.5	28.2	28.9	.127	.124	.121	87.2	88.3	87.8	1.654	.665
Aver.	39.7	38.9	39.3	.186	.179	.182	77.5	83.9	80.7	25.625	20.785
1818,	41.1	39.7	40.4	.187	.181	.184	77.4	84.4	80.9	27.397	20.056

Monthly Extremes.

1819.	Thermometer.				Barometer.				Hygrometer.					
									Point of Deposition		Moist. in 100 cub. in of air.		Relative Humidity.	
Months.	Highest.	Lowest.	Greatest range in 24 hours.	Least range in 24 hours.	Highest.	Lowest.	Greatest range in 24 hours.	Lowest range in 24 hours.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
Jan.	52.0	21.0	17.0	4.0	30.360	28.690	1.100	.050	44.6	22.4	.204	.097	100.0	72.6
Feb.	49.5	21.0	16.5	5.0	29.900	28.770	.748	.030	42.4	21.0	.191	.082	100.0	52.0
March	55.0	26.0	18.0	5.0	30.144	28.892	1.133	.030	44.6	12.0	.204	.068	98.0	41.0
April	58.0	31.0	21.0	5.5	30.150	28.935	.453	.005	45.6	22.4	.211	.097	100.0	48.0
May	63.0	30.0	25.0	5.5	30.060	29.415	.365	.005	53.0	7.0	.268	.057	96.0	27.0
June	68.0	41.5	23.0	10.0	30.190	29.175	.630	.020	54.8	31.4	.284	.132	94.0	42.0
July	74.0	42.5	22.5	8.5	30.235	29.170	.355	025	64.0	38.4	.381	.167	95.0	54.0
Aug.	79.0	47.0	19.0	8.0	30.335	28.740	.375	.015	64.6	43.0	.386	.194	97.0	53.4
Sept.	67.5	38.0	23.0	4.5	30.420	29.020	.540	.010	59.4	32.4	.328	.137	98.0	52.4
Oct.	63.0	26.5	22.5	3.0	30.230	29.225	.460	.030	57.6	15.4	.309	.076	99.0	47.0
Nov.	50.0	20.5	19.5	5.5	30.165	28.980	.685	.110	43.4	19.0	.197	.087	100.0	51.0
Dec.	51.5	9.5	19.0	2.0	30.295	28.840	.705	.010	47.4	18.6	.225	.086	100.0	62.0

I have annexed to the above tables the results of my observations in 1818, chiefly for the sake of some very remarkable coincidences between the two years. The most striking are the range of the thermometer and barometer, the absolute and relative humidity of the atmosphere, and the quantity of evaporation. My journal for 1817 does not exhibit the range of the barometer, but in other respects it gives results almost exactly the same as the above. The mean daily range of the thermometer for that year is 12.4. I am, Sir, yours, &c.

Feb. 26. 1820. ROBERT GORDON.

ART. XXXI.—*Quarterly Abstract of the Diurnal Variation of the Magnetic Needle.* By Colonel BEAUFOY, F. R. S.

MONTHLY mean Variation of the Magnetic Needle,
Variation West.

		1817.	1818.	1819.
NOV.	Morning,	24° 31′ 49″	24° 33′ 24″	24° 32′ 42″
	Noon,	24 37 55	24 41 41	24 38 43
DEC.	Morning,	24 34 03	24 37 04	24 33 29
	Noon,	24 38 02	24 41 20	24 37 20
		1818.	1819.	1820.
JAN.	Morning,	24° 34′ 02″	24° 35′ 42″	24° 34′ 06″
	Noon,	24 39 57	24 39 54	24 37 54

Owing to the shortness of the days, the evening observations were discontinued.

BUSHEY HEATH, STANMORE,
Feb. 9. 1820.

ART. XXXII.—*Proceedings of the Royal Society of Edinburgh.* (Continued from p. 181.)

Dec. 20. 1819.—A PAPER was read by Henry Mackenzie, Esq. *On the English Poets, considered with reference to their lyrical Poems.* This paper was an Appendix to his account of Mr John Home, and was prefaced with a short notice of the loss which the Society had suffered in the death of two of its distinguished members, Lord Webb Seymour and Mr Playfair.

Jan. 3. 1820.—Sir George Mackenzie, Bart., read a Paper, entitled, *Speculations on the Nature of Sound.* The facts which he chiefly dwelt upon were, first, That in every experiment, air has intervened between all bodies supposed to have the power of emitting and of conducting sound, and the apparatus of the ear; 2. That sound varies in quality, and that the *quality* is not altered by transmission through different media, although the *intensity* of the sound may be increased or diminished; 3. That the intensity of sound does not depend on the rate of vibration; 4. That different substances have the power of modifying the quality of sound; 5. That there are cases in which sounds interfere with one another; 6. That the same effect, in acquiring any pitch of sound, may be obtained by preserving a spring of the same length, while the volume of air connected with it is altered in dimension, (as in playing on a Jew's harp); or by keeping the volume of air the same, while the dimensions of the spring are altered, (as in the trumpet of an organ). Sir George Mackenzie's opinions, as far as they were stated, are, 1. That sound is a medium *sui generis;* 2. That this medium is emitted by no other substance but air; 3. That it is not conducted through air, but that successive portions of air, when put into a certain condition by impulse, emit it; and that when the impulse reaches the air in connection with the tympanum, the sound emitted by that portion of air alone, is made perceptible to us by the apparatus of the internal ear; and that we learn to judge of the distance of the body that gives the impulse, in a manner analogous to that by which we judge of the distance of objects in perspective; and that our acquaintance with sounds, as they proceed from impulse given by certain means, is derived from an imperceptible induction, similar to that by which a child learns the meaning of words, and forms correct ideas of distance. Lastly, That all means of producing sound, are only means of causing air to emit it.

Jan. 17.—Dr Fergusson, Inspector of Hospitals, read a paper *On the Nature and Properties of the Marsh Poison,* as known under the titles of *Marsh Miasmata* and *Malaria.* The author endeavoured to prove, from a reference to the medical topography of various places in the South of Europe and the West

Indies, that the universally received opinions of aqueous and vegetable putrefaction, single or combined, being the sources of this poison, were unfounded; that putrefaction under any shape had no effect in producing it; that it never emanates from water in bulk, however putrid that water may be, nor is necessarily an exhalation from marshes, but some modification of the state of the atmosphere by heat and moisture, being the product of a highly advanced stage of the drying process in absorbent soils, that had previously and recently been saturated with water. The illustrations were principally taken from the countries where the author had served with the British armies during the last twenty-five years, and exhibited a great variety of facts and observations in support of the opinions the paper professed to advocate. Other properties of the marsh poison, such as its particular adherence to and attraction for lofty umbrageous trees and rising grounds in the neighbourhood of swamps; its concentration in ravines, hollows, or leeward localities; its absorption from passing over water, and rarefaction or dissipation by the sun's heat, and regular currents of wind, were also pointed out and illustrated. In the course of the paper, the author, while treating of the effects of the marsh poison, was led to consider its extreme and most baleful product,—the yellow fever of the tropics;—and the non-contagious nature of that disease, was established by a series of facts and arguments that appeared to be incontestible. It concluded with some observations on the mode of reception of the marsh poison into the human constitution, whether by the lungs, the stomach or the skin, which last the author seemed to think was the most probable channel, and supported his opinion by some illustrations taken from the plague of the Levant, and the peculiar idiosyncracy of the African or Creole Negroes.

Jan. 26.—At a General Meeting of the Society, the following members were elected:—

HONORARY MEMBERS.

His Royal Highness the Prince Leopold.
His Imperial Highness the Archduke John.
His Royal Highness the Archduke Maximilian.
M. le Chevalier Delambre, Perpetual Secretary of the Academy of Sciences.

Ordinary Members.

James Hunter, Esq. of Thurston.
Right Honourable David Boyle.
James Keith, Esq.
Right Honourable Sir Samuel Shepherd.
James Nairne, Esq.
John Colquhoun, Esq.
Henry Raeburn, Esq.
Lieutenant-Colonel M. Stewart.
Charles Babbage, Esq. F. R. S.
Thomas Guthrie Wright, Esq.
John F. Herschel, Esq. F. R. S.
Adam Anderson, Esq. A. M.
John Shank Moré, Esq.
William Hall, Esq. A. M.
Dr George Augustus Borthwick.
Robert Dundas, Esq. of Arniston.
Dr Samuel Hibbert.
James Robinson Scott, Esq.
Dr Robert Haldane.

Feb. 7.—A paper by the Rev. Mr Holland was read, *On the Radiation of Caloric, and the apparent Radiation of Cold.*

At the same meeting, a paper by Dr Brewster was read, *On the Mean Temperature of the Earth.* The object of this paper was to explain a new and very simple formula for finding the mean temperature of any place in the western region of the old world, at all latitudes; to point out its remarkable accordance with the fine series of observations collected and arranged by M. Humboldt. The formula given by Dr Brewster, was,

$$T = 81^\circ.5 \text{ Cos } L.$$

T being the temperature at the level of the sea in degrees of Fahrenheit's scale, L the latitude of the place, and 81°.5 the mean temperature of the Equator, as deduced by Humboldt. This formula gives, to a surprising degree of exactness, the mean temperature of the parallel of 78° in the Greenland Seas, as ascertained from numerous observations by Mr Scoresby; and from its coincidence with observations at the Equator,—in the parallel of 45°,—and in the Arctic Regions, there can be little doubt, that the mean temperature of the North Pole differs very little from 0° of Fahrenheit, in place of being 32°, as assumed by Mayer and others. The formula of Mayer errs no less than *nine degrees* in the latitude of 78°. The paper was accompanied with a table of the ascertained mean temperature of thirty-one places, compared with the new formula and that of Mayer. The sum of the errors of Mayer's formula was 76°.73, 3.0 being positive and 1 negative. The sum of the errors in the new formula was 26°.41, the positive errors being 14°.24, and the negative ones 12°.17.

Feb. 21.—Henry Mackenzie, Esq. read a continuation of his paper *On the Dramatic Poets of Scotland.*

Art. XXXIII.—*Proceedings of the Wernerian Natural History Society.* (Continued from p. 182.)

Dec. 11. 1819.—THE Secretary read a paper by Mr Stewart, Lecturer on Botany, communicating a *New habitat of Buxbaumia aphylla.* This curious moss was found by him in Wedenshope, Peeblesshire, in October last. The plant grew chiefly on the abrupt declivities of little hillocks of peat-moss, perfectly destitute of other vegetation; though some, and these the most luxuriant plants, were found under heath, lichens, &c. He mentioned, that he had, in several instances, found more than one fruit-stalk from the same bulb, and these in very different stages of vegetation: One for instance decayed, with the flat side of the capsule detached for half way down from the summit, from the gibbous side,—the state in which some of Buxbaum's original specimens seem to have been,—but which had never occurred to the observation of Linnaeus, and hence his too severe criticism of Buxbaum; a second nearly mature, with the operculum not yet detached; and a third, (or a pistil rather,) with the calyptra not yet detached from the base. Having observed the slow growth of the capsule in some specimens gathered in October 1818, *for four months*, which vegetated freely for that period in a flower-pot, Mr Stewart was induced to conclude, on finding three fruit-stalks in such different stages of vegetation as those above described, that the plant could not be annual, as it has hitherto been stated to be by authors. Mr Stewart, it may be added, described the *leaves* of this supposed *aphyllous* moss in his course of Lectures on Cryptogamic Botany, during the winter of 1818–19. They are palmate, or much laciniate, and reticulate like the substance of a jungermannia.

Dec. 24.—Professor Jameson read a *Description of the rocks at Sandside Bay in Caithness*, from which it appears that they are of syenite, granite, limestone, conglomerate and sandstone, and all apparently of cotemporaneous formation.

Jan. 15. 1820.—Mr Butter read a paper on the *Change of Plumage which is sometimes observed in aged female birds to* *that of the male.* And Professor Jameson read *some Observations on the Moulting of Birds*, and explained particularly the *change of colour*, which takes place in some species on the approach of winter, and from which it appeared not only that the old feathers become white, but that an additional quantity of new ones are at the same time produced. At this meeting, Professor Jameson exhibited a specimen of the water-rail, prepared some years ago by Dr Willis, in order to shew the *spine on the winglets* of the water-rail, and the Professor at the same time pointed out spines of the same description he had detected in the common water-hen, and in several foreign species of the same genus.

Jan. 29.—Professor Jameson, at this meeting, read a *Series of observations on the phenomena presented at the line of junction of quartz-rock and limestone*, from which it appears that they are of the same description as those observed at the junction of trap and limestone. He also pointed out several phenomena of a similar nature, which he had noticed at the meeting of limestones having different textures.

Feb. 12.—Dr Yule laid before the Society a communication regarding a *Collection of rare plants in a living state, received from Dr Wallich of the Calcutta Garden*, and conveyed to this country with great care by Colonel Udny Yule, with remarks on the most effectual means of transporting plants and seeds safely from distant tropical countries. At the same meeting, Professor Jameson read a paper on *Thermal Rocks*, &c. which is printed in this number of our Journal, p. 307.

ART. XXXIV.—SCIENTIFIC INTELLIGENCE.

I. NATURAL PHILOSOPHY.

ASTRONOMY.

1. *Obliquity of the Ecliptic.*—It has generally been supposed by astronomers, that the observations of the winter solstice give a less obliquity of the ecliptic than those of the summer solstice. M. Bessel has recently called this opinion in question, and shews that Bradley's observations give the same result both in summer and winter. His own observations also give a similar result. Dr Brinkley thinks that the difference arises from

some unknown modification of refraction, and he has found that, at the winter solstice, an irregularity of refraction takes place for the sun, greater than for the stars at the same zenith distance. See *Phil. Trans.* 1819, p. 241.

2. *Aberration of Light.*—Dr Brinkley has found the maximum aberration of light to be 20″.80, much greater than it has been believed to be. This result has been confirmed by M. Bessel, who, from several investigations in the Greenwich observations of Dr Bradley, makes the maximum 20″.70. See *Phil. Trans.* 1819, p. 246.

3. *Transparency of the Comet of* 1819.—Dr Olbers having calculated that the comet of 1819 would pass over the sun's disc on the 26th of June 1819, it became desirable to ascertain if any spots were seen on the sun's disc at that time. Major-General Lindener of Glatz, had fortunately observed the sun on that day at 5, 6 and 7 o'clock, with a good telescope of Ramsden's, but *no spot was visible.* On the 27th, in the morning, he observed a small spot.

4. *New Comet.*—M. Blanpain has discovered at Marseilles, a comet in the constellation Virgo. On the 28th Nov. at 5^h, its right ascension was 180° 31′, and decl. 0° 20′ S. On the 2d Dec. at 5^h, its right ascension was 185° 6′, and its decl. 2° 20′ N.

5. *Solar Eclipse of the 7th September* 1820.—The following list of places where this eclipse will be *annular*, has been communicated to us by Mr Charles Rumker of Hamburg. The calculations for Hamburg were made by himself, and for the other places by M. Gerling.

Places.	Mean Time.			Shortest distance of the centers,	Place of the first impression from the zenith of the ⊙ to the west.
	Beginning.	Middle.	End.		
Göttingen,	1^h 14′ 27″	2^h 41′ 04″	4^h 01′ 12″	16″.1	67°
Seeberg,	1 19 46	2 46 17	4 6 10	23.5	69
Bremen,	1 06 00	2 32 21	3 52 42	14.6	65
Hamburg,	1 11 10	2 36 11	3 36 56	44.4	65½
Manheim,	1 10 31	2 38 19	3 59 09	38.0	64

6. *Astronomical Society in London.*—We congratulate the friends of science on the recent establishment of an Astronomi-

cal Society in London, which already contains many of the most distinguished names in Great Britain. The object of the society is to encourage and promote Astronomy, "by collecting, reducing, and publishing useful observations and tables; by setting on foot a minute and systematic examination of the heavens; by circulating notices of all remarkable phenomena about to happen, and of discoveries as they arise; by proposing prizes for the improvement of particular departments, and bestowing medals or rewards on successful researches in all; and, finally, by acting, as far as possible, in concert with all institutions, both in England and abroad, whose objects have any thing in common with their own, but avoiding all interference with the objects and interests of established scientific bodies."

OPTICS.

7. *Harmotome.*—Dr Brewster has found, that this crystal has *Two axes of double refraction;* and therefore it *must* have a primitive form different from the octohedron with a square base, which Haüy assigns to it. The Count de Bournon had long ago, from mineralogical reasons, supposed that Haüy had given it a wrong primitive form.

8. *Meionite.*—This crystal has been found by Dr Brewster to have *One* axis of double refraction, coincident with the axis of the prism. The action of this axis is *Negative,* like that of Iceland-crystal. The indices of refraction are,

Ordinary refraction,	1.6058
Extraordinary refraction,	1.5763

9. *Petalite.*—This interesting mineral, from which is obtained the newly discovered alkali called *Lithion,* has been found by Dr Brewster to have a perfect crystalline structure, and to possess *Two axes of double refraction.*

MAGNETISM.

10. *Variation of the Needle at Lyons.*—The following measures of the variation of the needle were obtained at Lyons.

1751, Nov.	15°.45′ W.	1757, Dec.	17°.15′ W.
1752,	16.00	1760,	18.30
1755, Dec.	16.30	1761,	18.45

Zach's *Corresp. Astr.* i. 223.

METEOROLOGY.

11. *Red Rain.*—On the 2d of November in the afternoon, a red-coloured rain fell at Blankenburg and Dixmude, in Flanders. In the following night the same happened at Schevenningen. When analysed, it yielded the hydrochlorate of cobalt.—*Annales Generales des Sciences Physique.* Bruxelles *.

12. *Black Rain.*—The following account has been published in the American Journals: " *November 23. 1819. Awful Storm at Montreal.*—The dark and thick weather which was experienced in this city some time back, extended throughout the United States, as well as the neighbouring provinces. In the district of Maine, the darkness was very great at times, during which there were occasional peals of thunder, and very vivid lightning. The appearance of the firmament was awfully grand and terrific, which gave rise to the most fearful apprehension in the minds of many persons. In Montreal, also, the darkness was very great, particularly on a Sunday morning; the whole atmosphere appeared as covered with a thick haze of a dingy orange colour, during which rain fell of a dark inky appearance, and apparently impregnated with some black substance, resembling soot. At this period many conjectures were afloat, among which, that a volcano had broken out in some distant quarter. The weather after this became pleasant, until the Tuesday following, when, at 12 o'clock, a heavy damp vapour enveloped the whole city, when it became necessary to light candles in all the houses; the stalls of the butchers were also lighted. The appearance was awful, and grand in the extreme. A little before 3 o'clock, a slight shock of an earthquake was felt, accompanied with a noise resembling the distant discharge of artillery. It was now that the increasing gloom engrossed universal attention. At twenty minutes past 3, when the darkness seemed to have reached its greatest depth, the whole city was instantaneously illuminated by the most vivid flash of lightning ever witnessed in Montreal, immediately followed by a peal of thunder, so loud and near as to shake the strongest buildings to their foundation, which was followed by other peals, and accompanied by a heavy shower of rain, of the colour

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* This Journal is edited by Bory de St Vincent, Van Mons, and Drapiez.

above described. After 4 P. M. the heavens began to assume a brighter appearance, and fear gradually subsided. Between 4 and 5 it was discovered that the steeple of the French Church in Notre-Dame Street was on fire. The flames were seen issuing from the top of the spire, which, through the haze, had the appearance of a lighthouse seen far at sea. A small engine was taken up the steeple, and the fire extinguished, after great exertions, between 8 and 9 o'clock at night. At 8 o'clock the iron crucifix fell with a tremendous crash, and broke in several pieces."

13. *Snow in Rome.*—In the month of January last, snow fell in Rome, which lay three days on the roofs and in the streets.

14. *Mean Temperature of the Year.*—Such of our readers as keep meteorological journals, will confer upon us a particular favour, by transmitting to us the average temperature of the year, as obtained from their observations, and also a statement of the number of years from which it is deduced, and of the place of observation above the level of the sea.

II. CHEMISTRY.

15. *Saussure's Experiments on the Decomposition of Starch.*—A very interesting Memoir by M. Theod. de Saussure has been published in the *Phil. Trans.* for 1819, part I. The following are the principal results of his investigation. Starch, when reduced to the state of paste, and allowed to decompose spontaneously at a temperature between 68° and 77° Fahrenheit, produces, either by the contact of air or without it, (1.) A species of sugar, similar to that which is obtained from it by the means of diluted sulphuric acid. (2.) A species of gum, which has a great resemblance to the gummy principle of roasted starch. (3.) A substance which Saussure calls *Amidine*, possessing properties intermediate between those of starch and the preceding gum. (4.) A substance approaching to ligneous, by its insolubility in water and in several acids; but it has an amylaceous character, in giving a purple tinge to an aqueous solution of iodine.

The spontaneous decomposition of starch furnishes also other products, but their presence and mode of formation are subordinate to the action, or to the absence, of the atmospherical air during the fermentation. When the decomposition takes place *with the contact of air*, the starch produces much water, into which the atmospherical oxygen gas does not enter as a constituent principle. It is formed from the carbonic acid gas, the oxygen of which belongs to the atmospherical air. The starch deposites charcoal, which browns all the products of the operation. The weight of the dry residue is less than that of the soap employed. When the decomposition takes place *without the contact of the air*, the starch produces no water, but disengages a small quantity of carbonic acid gas, and pure hydrogen. It deposites no charcoal. The weight of the dry residue is equal to that of the soap employed.

16. *Phosphoric Acid in Vegetables.*—Mr Barry of Plough Court, London, has discovered, in the preparation of pharmaceutical extracts by evaporation *in vacuo*, "that all those vegetables which are cultivated, seem to contain phosphoric salt in great abundance."

17. *New Differential Thermometer.*—Dr Howard has described in the Journal of the Royal Institution a new differential thermometer, which differs only from the thermoscope of Count Rumford, or the differential thermometer of Leslie, in having the bulb filled with the vapour of alcohol or ether in place of air. An instrument of this kind has been exhibited for many years by the eminent Professor of Chemistry in the University of Edinburgh, and for magnifying the effect of small degrees of heat. He found it, however, as Dr Howard will also do, to be entirely unfit for the purpose of measuring *differences* of temperature. The same remarks apply to Mr Brand's idea of converting it into a Photometer.

18. *Braconnot's method of dying Wool, Silk, Cotton and Hemp, a fine Mineral Yellow Colour.*—The substance which M. Braconnot recommends for this purpose is realgar, or the sulphuret of arsenic. Having mixed 1 part of sulphur, 2 parts of the white oxide of arsenic, and 5 parts of potash of commerce, melt them in a crucible at a heat near that of redness. The yellow mass thus obtained is to be dissolved in hot water, and the liquor filtered, to separate it from a sediment. It is then to be diluted with water, and sulphuric acid poured upon it, of such

a strength as to produce a fleecy precipitate of a superb yellow colour. This precipitate, washed on a cloth, dissolves with extreme facility in ammonia, and gives a yellowish liquor, into which is poured an excess of ammonia, to discolour it entirely. In this liquor the goods to be dyed are plunged; and all shades of yellow may be obtained, by diluting it with water. When the stuffs are taken out, they are colourless, but they assume gradually the yellow colour as the ammonia evaporates. In the above operation, all metallic utensils must be carefully avoided. The colour thus obtained is more durable than the material which is dyed. It resists all agents excepting the alkalies, and may be used in tapestry, velvets, and other stuffs for furniture, and also for painted papers.—*Ann. de Chim. et de Phys.* tom. xii. p. 98.

19. *Ulmine from Wood.*—M. Braconnot has discovered that artificial ulmine may be obtained from wood, by the action of potash. He has found it in great abundance in turf, and in a variety of ligneous earths. He considers it as a constituent part of soot, but he could not produce it with oil.

20. *Clegg's New Method of producing Coal-Gas.*—Mr Clegg has contrived a new apparatus by which he can produce 25,000 cubic feet of coal-gas from one chaldron of Newcastle Wallsend coal, without generating either tar or ammoniacal liquor, being 15,000 cubic feet more than was formerly produced. The coal is introduced, by a mechanical process, in strata not exceeding half an inch in thickness. In this way, the retorts are kept at an uniform heat, and the coal is completely and rapidly decomposed, so that the whole of the hydrogen combines with the charcoal, constituting olefiant gas; and the matter which usually escaped in the form of tar and ammoniacal liquor is perfectly decomposed. The expence of producing 50,000 cubic feet of gas in twenty-four hours on the old plan is L. 3817; upon the new plan L. 1123; and the expence of producing an equal quantity of light from oil L. 19,010.

21. *Cadmium.*—Dr Clarke of Cambridge has discovered cadmium in the radiated blende of Derbyshire. Several chemists in London have confirmed this discovery, and have detected the same metal in other ores of zinc.

22. *New Ore of Nickel.*—A new ore of nickel, made known but not described by Cronstedt, has been analysed by Professor Pfaff of Kiel. Its specific gravity is 6.129; and it is composed of—

Nickel,	24.42
Arsenic,	45.90
Iron,	10.46
Sulphur,	12.36
	93.14

III. NATURAL HISTORY.

ZOOLOGY.

23. *Notices of Works publishing in Italy on Human and Comparative Anatomy.*—A posthumous work of the late celebrated Paolo Mascagni (author of the splendid Views of the Lymphatic System) is now ready for publication at Florence. This work was begun so far back as the year 1787. His design is to exhibit, by a series of Engravings, connected views of all the parts of the Human Body, as they appear in nature, proceeding from the surface inward, in the order of the several layers of muscles. It was found, however, that to have united the absorbent vessels with the arteries, veins, and nerves, would have rendered the figures excessively complicated, and their demonstration confused and obscure; wherefore, the bloodvessels and nerves alone, as they occur near the surface of the body, are exhibited in connection with the other organs. The better to characterise each system of organs, they will be represented in different styles of engraving; so that muscular fibre shall at once be distinguished from tendon or bone, arteries from veins and from nerves, &c.; and still better to insure this object, in some copies, all the parts will be coloured according to nature. To preserve distinctness and exact relative position of parts, each figure will be of a size not less than natural. The external superficies of the body will be contained in two figures, each about 3 braccia of Florence, or 5 feet of Paris. One will represent a front, and the other a back view; and such parts as could not well be exhibited in the *entire* figure will be represented in *separate* views, of which there will be *eight* connected with the above two figures, representing the axilla, the mamma; the organs of generation, male

and female; the ear and eye magnified; the head, in different aspects; and the feet. These two figures, which represent the *first* layer of muscles, with the nerves and bloodvessels, will form the *first fasciculus*. Two other figures of the same size, representing back and front views, will be devoted to the *second* layer of muscles, with the corresponding vessels and nerves. And two others, also of the same size, will exhibit the *third* layer of muscles, with the bloodvessels, nerves, and lymphatics. And, lastly, two equally large will represent the skeleton in different aspects, together with the arteries which enter, and the veins and lymphatics which proceed from it. Each fasciculus will have, in addition, plates of the viscera contained in the three great cavities, in union with their arteries, veins, and nerves. Copious explanations, with annotations, tending to establish, on a certain basis, every anatomical fact, will be appended; and the facts most uniform and constant will be noticed. Outline drawings, for the explanation of the plates, will be attached; and, besides letters of reference placed on the respective parts, the denomination most in use by others will be subjoined.—Some of the designs for this work were executed under the author's inspection by Ciro Santi, by whom the plates of the work on the Lymphatic System had been drawn and engraved; others by Guerrini and Santorini, artists of the greatest ability; and the engravings are by Carlo Lasinio, and other distinguished artists. The work was entirely finished before the death of its illustrious author, and is now to be published by his heirs. The conduct of the publication is entrusted to Signior Antommarchi, a distinguished pupil of the author, and afterwards his successor in the chair of anatomy in Florence. This great work will be published by subscription. The price to subscribers will be 65 zecchini (about 10s. 6d. each) of Florence with the plates *plain*, and 85 for those *coloured*. Non-subscribers will pay 70 zecchini for the work in black, and 90 for it coloured. We have been assured by an intelligent gentleman, who has seen the work, that the *coloured* copies are greatly preferable to the *black* in point of distinctness,—a circumstance of the greatest consequence in figures of so complicated a nature. This work is preceded by a Prodromus, written in Italian, and to be afterwards translated into Latin, the object of which is, an examination of all the elements of the parts which constitute the human body. It contains microscopical discoveries in the structure of these parts, which will lead to new views in physiology and pathology; and is illustrated by 22 plates, some of which present also demonstrations of the absorbent vessels of vegetables. This work has already reached this country. It is printed in folio, and both the typography and engraving are very finely executed. It was published by Marenigh of Florence. Its price is nine zecchini. Some time before his death, Mascagni published also an anatomical work for the use of artists. It is entitled, " Anatomia per uso degli Studiosi di Pittura e di Scultura." It may be had of Marenigh of Florence. The price is 90 paoli with the plates plain, and 100 with the plates coloured. This work is said to be most correctly and beautifully executed. Each fasciculus will cost about 45½ francs, but to non-subscribers the price will be raised one-third. Application for the work may be made at Padua, to the Directeur de l'Imprimerie du Séminaire, and at Milan to Carlo Brizzolaza, Corsia dei Servi.

Dr Poli of Naples is employed on a *second* edition of his magnificent work, entitled, " Testacea utriusque Siciliæ." The first edition consisted of 2 volumes folio. The new one will comprise 3 volumes.

Dr Mauro Rusconi of Pavia, who published, in 1817, a dissertation, entitled " Descrizione Anatomica degli organi della circolazione delle Larve delle Salamandre Aquatiche," illustrated by excellent designs, has lately, in conjunction with Professor Configliachi, the successor to the chair of Volta, finished a work on the Natural History and Anatomy of the Proteus Anguineus, at present but imperfectly known. The history of the animal is given by Professor Configliachi, who has enjoyed the best opportunities of studying its habits, &c.; and its anatomy by Rusconi, the favourite pupil of Scarpa, who not only excels as an expert anatomist, but delineates ably as an artist. The engravings will be executed by the artist who so admirably performed that duty for Scarpa, in his work on Aneurism. It is on its way to this country.

In comparative anatomy, a splendid work is publishing at Padua, by Dr E. A. Renier, Professor of Natural History in the

Imperial and Royal University of that city. For the last thirty years, he has devoted himself to researches on the living animals of the Adriatic Sea. He has observed them in all states and seasons, and anatomised them with the greatest care; and by these means has succeeded in discovering many new beings, and been able to rectify, in many particulars, what has been written on those previously known. More than 100 designs of animals, with their anatomy coloured according to nature, are already finished. Most of these have been executed by the Professor himself, and the remainder by able artists under his inspection. These designs have been engraved with the utmost care, by artists of the greatest reputation. The title of the work is, "Observazioni sopra alcuni animali dell' Adriatico, fatte dal dott. Stefano Andrea Renier, Professore," &c. The printing of the above work will be conducted under the eye of the author in the Italian and Latin languages, placed in opposite columns, in folio. The types have been cast expressly for the work. The plates also will be in folio, and on fine paper: those in outline, for reference, in *black*; and those of the figures in *natural colours*. The work will be published in numbers, by subscription. Each number will contain six plates of coloured figures; six other plates in outline, black; and about fifteen sheets of printing. The first number or fasciculus was announced for publication in March 1816, and the others were to follow at intervals of three months.

24. *On the Proteus.*—This remarkable animal, which has been hitherto found only in lakes in the limestone caves of Carniola, has been particularly examined by an able Italian naturalist, Rusconi. He confirms the observation of Schreibers in demonstrating the existence of organs of generation, which proves that it is not a larva of any of the amphibia, as had been conjectured by some naturalists. The part which Cuvier describes as the lungs, he maintains has neither pulmonary arteries nor veins; hence cannot be considered as true lungs; and he finds that the respiration is performed by means of gills. In short, Rusconi is of opinion, that the Proteus is a perfect reptile, differing from all other reptiles, in not having, like them, a simple respiration, but resembling fishes, in respiring by means of branchiæ or gills.

25. *New Fossil Species of Glutton.*—The limestone caves of Gailenreuth in Germany, have been long famous on account of the remains of unknown animals which they contain. Esper, Rosenmüller, Blumenbach, and Cuvier, have published accounts of these caves and their contents. Three-fourths of the bones found enveloped in the calcareous tuffa, and earthy matter, belong to two species of bear, viz. *Ursus spelœus* and *arctoideus;* one-half or two-thirds of the remaining fourth belong to a species of *Hyœna.* A very small number of these remains belongs to a species of the genus *lion* or *tiger;* and another to animals of *the dog* or *wolf kinds;* and, lastly, the smallest portion belongs to different species of small carnivorous animals, as the *fox* and the *polecat.* Very lately a German naturalist, Dr August Goldfuss, has detected another unknown species of bear, which he names *Ursus priscus,* and a skull and other parts of a quadruped very nearly allied to the *Mustela gulo* or *glutton.* An account and figures of the skull have been published in the *Nova Acta* of the Academiæ Cæsareæ Leopoldino Carolinæ Naturæ Curiosorum, vol. ix. 1818.

We intend, in an early number, to lay before our readers an account of the quadrupeds and birds which have disappeared from this country, and now either live in other countries, or are extinct.

26. *Occurrence of the Sea-Horse* (Walrus or Morse, *Trichecus rosmarus,* Lin.) *in the Hebrides.*—Mr W. Macgillivray has communicated to us a notice in regard to the occurrence of the Walrus in this country. He says, that in the end of December 1817, a large unknown marine animal was seen near the mouth of Loch Seaforth, an arm of the sea which separates the islands of Lewis and Harris. A few days after, it was discovered by some of the inhabitants, lying upon a small rock at the Sound of Stockness, on the east coast of Harris. One of them, an expert marksman, prevailed upon the rest to venture out with a boat, in order to attack it. He landed upon another small rock near that on which the animal was reposing, and taking a deliberate aim, discharged his musket at it. The animal immediately plunged into the sea, to appearance unhurt; but keeping its head and part of the body above water, presented an opportunity of lodging two other shots, the last of which, passing

through the chest, proved fatal. It was then secured, by fixing a rope to its tusks, and dragged ashore after the boat. Mr Macgillivray hastened to the spot, and carefully examined the animal, which proved to be the *Sea-Horse* or *Morse*. It was upwards of ten feet in length; and two barrels of blubber were obtained from it. The tusks, now in the possession of Mr Macleod of Harris, measure eight inches and a half in length. The inhabitants considered it as a supernatural being, adapting to it the ideas which they usually associate with the *Each Uisg* (Water-Horse) an imaginary entity, and the *Seilch Uisg*, an animal supposed, and asserted by people in other matters not unworthy of credit, to have been seen on several lakes in Harris and Lewis, particularly in Loch Languad, which is about twelve miles in length. The largest and most perfect specimen of the sea-horse in any collection in Europe, is that in the College Museum in Edinburgh, which was presented to Professor Jameson by Captain Scoresby.

27. *Intestinal Worms.*—Intestinal worms, although they may appear to the superficial observer as objects of little consequence in the grand scale of being, afford to the naturalist a most interesting field of observation. Their wonderful distribution in the most secret parts of the animal frame; their remarkable structure and economy: their apparent equivocal generation; their connection and relations with some internal, and many external affections of the animal system; and their occurring in and characterising the different species of animals, from man downwards, prove the important rank they hold in natural history and in medicine. Their history and economy were studied by the great Haller; and our late illustrious Monro, one of the most distinguished physicians Europe ever produced, considered them as objects of the highest interest and curiosity. Rudolphi, the celebrated Professor of Anatomy in Berlin, so well known to all the anatomists and naturalists of Europe, has, by the publication of his classical work on the intestinal vermes, which abounds in new facts and observations, increased in an eminent degree his already high reputation. And very lately Bremser, also a German naturalist, in his work, "Ueber lebende Wurmer im lebenden Menschen," has, by his investigations, descriptions, and ingenious views, still more increas-

ed the interest of this very curious and important branch of natural science. Knowing what has just been stated, we were exceedingly surprised to meet with the following absurd and impertinent remarks in a book of Travels just published, and that too in Edinburgh : " Museums, galleries of pictures, learned societies, and various collections of things that are not useful, abound in Berlin. One collection which deserves to be mentioned, from the evidence it affords of what learned triflers can employ themselves with, is a collection, in high preservation, of those worms which are sometimes found in the bowels of the human body, and whose existence there constitutes a particular disease. A Professor Rudolphi is the collector. A similar collection exists in Vienna, whose collector is not only thought to be a man of industry, but of talent. These gentlemen must very much need a decent occupation. To bestow professorships on them, and to honour them, seems to me like the vain worship of an idol. There is but one step lower in which learned uselessness can go in its filthy researches."

28. *White Swallow.*—Dr Traill of Liverpool communicates to us the following fact.—" On 22d August 1819, I found in the nest of the Hirundo rustica, at Greenbank, near this town, a perfectly white swallow, fully fledged. The nest contained another young bird of the usual colour. The plumage of the former was pure snow-white, with a gloss like sattin on the head, neck, wing-coverts and back. The animal was a perfect *albino*, having red eyes, pale reddish beak and legs. On replacing it in the nest, it speedily fled away, but was instantly attacked by fifty or sixty common swallows, that appeared to peck at and buffet it so cruelly, that it took refuge in a tree, from which it was not easily raised. On again essaying its wings, its persecutors assembled round it in great numbers, accompanying it until distance concealed it from our sight. A few days after, it was shot near its former habitation, and both it and its brother swallow are now in my possession."

BOTANY.

29. *Primitive form of Vegetable Cells.*—Kieser in a memoir " On the original and peculiar form of the cells of plants,"

published in the Nova Acta Physico-medica Acad. Cæsar. Leopold. Carolin. Nat. Curios. t. 9., maintains, that the original or primitive form of the vegetable cells, is the rhomboidal dodecahedron.

30. *Magnificent Flower.*—M. Decandolle lately mentioned to one of our correspondents, that a most magnificent and very singular flower had been discovered in the Island of Borneo, by the botanist who accompanied Sir Stamford Raffles to that island, after the cession of Java to the Dutch. The flower seems to rise immediately out of the ground, without stem, and without shewing leaves at the time of flowering. The flower, when expanded, is described as being fully a metre (more than a yard) in circumference, and in form somewhat similar to a gigantic Stapelia. It is of a red colour, beautifully veined with white. The unexpanded flower was compared to a large cabbage. We have heard that specimens of this curious production are in the possession of Dr Horsfield in London, and we shall doubtless soon be favoured with a correct description of it.

31. *Uses of Confervæ in the economy of Nature.*—This tribe of plants, one of the most simple in the vegetable kingdom, is very generally and abundantly distributed. When they grow in water, its putrefaction is said to be prevented, but they are principally important in the economy of nature, in forming by their decomposition, the first and earliest soil; and it is worthy of remark, that the bottom of the sea is gradually raised by a species of this tribe, named Conferva chthonoplastes. This remarkable conferva was first discovered by a Danish naturalist, who has figured it in No. 1485 of Flora Danica. Its closely aggregated fibres form slimy and variously coloured beds, with which the bottom of the sea is covered, and its level raised; and by its abundant spreading over rocks on sea-coasts, affords places of residence to other marine productions. The same is observed in springs, rivers and canals, where the soil, formed of confervæ, affords nourishment to the more perfect water-plants. Confervæ contribute in an eminent degree to the formation of peat, and probably serve as food to many water insects, and even to frogs and fishes.

32. *Dr Theodore Frid. Lud. Nies on the growth of Musci.*—Dr Theodore Nies, brother of the well known Nies of Esen-

beck, published in the year 1818 a Thesis, entitled, "De Muscorum propagatione commentatio." In this curious tract, the author traces several of the mosses from their first appearance through their various stages of growth to their perfect state. In their first stage, they appear as a greenish organised slime or jelly, with disseminated globules; next, in a fibrous form; and, lastly, as perfect mosses. Many of the Confervæ, as C. frigida and castanea, and Ulvæ, as U. rupestris, appear to be musci in their imperfect state. These observations are of the same general import with those of Mr Drummond, mentioned in this *Journal*, vol. ii. p. 192. It may be added, that some of the Lichens, before they attain their state of maturity, pass through the conferva form.

33. *Abstract of the general results which form the Basis of Gallesio's "Theory of the reproduction of Vegetables."*—Gallesio, an eminent Italian botanist, native of Genoa, published at Paris, in the year 1811, a Treatise on the Citrus, *(Traité du Citrus, par George Gallesio)*; and, in the year 1816, at Pisa, a curious work entitled *Teoria della Reproduzione Vegetale* *. Of these two works, which we believe are yet scarcely known in England, the latter may be considered as little more than an extension, and a translation into his native language, of the doctrines founded upon the experiments and observations contained in the former work. Gallesio's researches among the luxuriant gardens which line the beautiful shores of Liguria, have been extensive and multiplied. The following is an abstract of the general results which form the basis of his Teoria della Reproduzione Vegetale, and which it may be interesting to compare with those obtained by the researches of Knight, and other observers in our own country. 1. Nature has created *genera*. These form so many families, distinguished from each other by particular characters. 2. Nature has created *species*. These form so many branches of these families, to which they appertain by common characters. 3. The mixture of these *species* by sexual union, gives rise to

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* Gallesio is now engaged in an extensive and important work, the *Pomona Italiana*, of which two or three numbers have already been published, in a style highly creditable to the Italian press.

Hybrids. 4. The mixture and disproportion of the *principles of reproduction* of different individuals of the same species, give origin to *races* or *varieties.* 5. The forced action of one principle upon another in fecundation, when the elements of these principles belonging to different races have already undergone changes of organization, gives rise to *monsters.* 6. Hybrids, varieties and monsters, are therefore due to the *seed* only. 7. The seed equally gives origin to the *domestic* and *wild* varieties. 8. Culture has destined the first of these to provide grafts, the second to bear them. 9. Grafts or sets only can perpetuate these varieties in their natural state. 10. The seeds of these varieties are themselves, however, subject to the influence of fecundation, and capable of producing new varieties, either better or worse in kind. These afford types, when the fecundation takes place naturally. 11. Monsters are individuals, the organization of which has undergone a change in the process of fecundation. 12. If this change takes place in the *ovary,* the monstrosity is in the fruit which results from it, and perishes with it. 13. The monster is regularly *sterile,* or *semi-sterile;* either by the nature of the flowers, which either have not sex, or have only the female organ, or too small a proportion of the male; or by the nature of the fruit, which is either entirely without seed, or which has only sterile or abortive seed, or too little seed. Whence, it rarely happens that monsters can be multiplied by reproduction; but either grafting or sets are required for this purpose.

34. *Dr John on Potash in Vegetables, &c.*—In Professor John of Berlin's Prize Essay, published in Berlin in 1819, "On the Origin of Alkali and other Salts in Vegetables," we find the following facts. 1. Uncombined potash does not occur in living vegetables, it being always combined with an acid, and is only found in them when they are in a state of putridity or decomposition. 2. Plants that feel rough and sharp, particularly *equiseti,* contain much siliceous earth; in the latter fully 13 per cent. 3. Lichens that grow on the summits of fir trees, contain an uncommon proportion of oxide of iron, which, Dr John remarks, may be viewed as illustrative of the formation of iron by the vegetable process. 4. Dr John recommends the use of decaying and diseased wood to those who wish to obtain potash

from it by burning, as he maintains that the quantity of potash is much increased by the putrefactive process. This remark is not new, for we find it mentioned in the second volume of Schreber's *Sammlung verschiedener Schriften*, published in 1763, that putrid wood was recommended for obtaining ashes in preference to fresh wood. 5. Plants which were allowed to grow in a solution of natron, absorbed by their roots a considerable portion of the alkali; but none of this appeared when the ashes of the plant were examined: In place of it, appeared potash; and hence it is conjectured that vegetables have the power of converting natron into potash.

35. *Cultivation of Tea in Brazil.*—Mr Swainson informs us that it is not true, as is generally reported, that the Brazilian Government is making great exertions in introducing the tea-plant into Brazil. The fact is simply as follows: The late prime minister Arrugo brought a few Chinese to Brazil, with the view of making the trial of raising tea in that country, but both the soil and climate were found to be unfavourable, and the plan was immediately abandoned. The same misrepresentation exists in regard to the culture of the clove and other oriental spices in Brazil.

36. *Effect of Hot Water in reviving Flowers.*—In Thomson's Annals of Philosophy, it is said, that if flowers which have been twenty-four hours out of water and are decayed, are plunged into hot water, that, as the water gradually cools, they become again quite fresh. This fact, while many discredit it, has been long familiar to those who live in the vicinity of hot springs, and who have remarked, that decayed flowers plunged into the waters of the springs become again fresh and beautiful.

37. *New Febrifuge Bark.*—A new South American febrifuge bark, from a shrub known to the Indians under the name ***Chininha***, and which Dr Joseph Pavon of Madrid, arranges in the vegetable system as a new genus, under the title ***Unanuea febrifuga***, has been lately employed in the hospitals in Madrid, in place of the cinchona or Peruvian bark, and with distinguished success. According to the published report, the physicians have been enabled, by means of this new and powerful remedy, to cut short fevers which did not yield to the cinchona.

MINERALOGY.

38. *Dr Holland the Discoverer of Native Boracic Acid in the Crater of Volcano.*—In the first volume of the Transactions of the Geological Society of London, we are informed by the late Mr Smithson Tennant, that on examining a set of minerals, said to have been brought from the Lipari Islands, he found some of them encrusted with native boracic acid. This circumstance induced Dr Holland to search for this rare mineral in Volcano; and we find, on consulting his interesting book of travels, that he found it *in situ* in the crater of Volcano, so long ago as the summer of 1812. He describes it as appearing in small shining laminæ upon the surface of the sulphur, which has been sublimed, and covers in various places the sides and bottom of this vast cavity. It is, therefore, not correct, as stated in our last Number, that M. Lucas *jun.* was the first who observed this mineral in the Lipari Islands.

39. *Beudant's Geological Observations in Hungary.*—Beudant, an active, intelligent, and well instructed French geologist, has lately examined with great care and much accuracy, several of the most interesting districts in Hungary. His observations are now reading before the Royal Academy of Sciences; and we are informed, that the following are some of the statements to which he has directed the attention of that illustrious body. 1. The existence of a great body of trachyte or volcanic porphyry, which sometimes passes into porphyries, bearing a close resemblance to those associated with neptunian rocks. 2. The occurrence of great tracts of *pearl-stone* and of *obsidian*, forming a part of the trachyte series. 3. The distribution of vast deposites of breccias and tuffas around the trachyte hills, extending from them to a considerable distance into the flat country. These tuffas and breccias are formed by the decomposition of the trachyte rocks, and by the ejection of scoriæ, pumice, and cinders, which probably accompanied their formation. They contain opal, hyalite, and opalised wood. 4. The distribution of beds of regenerated porphyry over the tuffas and breccias, and which contain the famous *alum-stone* of Hungary. 5. The occurrence of a red sandstone formation, with included beds of pitchstone. 6. The discovery of a chalk formation, and of

parts of the Paris formation. The highly important and interesting geological travels of Beudant, will appear in June, and are to be illustrated by two large geognostical maps.

40. *Gerhard on the Chemical formation of compact and granular Strata, and of conglomerated Rocks.*—Professor Jameson, in various papers in the public Journals, and in the Memoirs of the Wernerian Society, maintains the chemical formation of strata, whether compact, granular or conglomerated. This mode of formation is not peculiar to rocks of the primitive class, but extends to the transition and secondary classes, many of the members of which, whether they appear in vast imbedded masses, like granite and porphyry, or in beds or veins, Professor Jameson considers as chemical and cotemporaneous in the formation. Gerhard, in the Memoirs of the Royal Academy of Berlin, for 1819, advocates the same opinion, and it has been extensively employed by Dr Hibbert in his account of the Shetland Islands, published in this Journal. We shall in our next number state Gerhard's views.

41. *Charpentier's Geognosy of the Pyrenees.*—Charpentier the younger, an elevé of the Wernerian school, who has already distinguished himself by his geognostical investigations, has in the press a complete account of the geognosy of the Pyrenees. We are informed that this work is distinguished by its excellent arrangement, accurate descriptions, legitimate inferences, and the new and important facts with which it abounds.

IV. GENERAL SCIENCE.

42. *New Membrane in the Human Eye.*—Dr Jacob of Dublin has recently discovered a new membrane in the human eye, of the same nature as that which lines serous cavities, and covering the retina from the optic nerve to the ciliary processes. In the sheep, ox, and horse, or any other individual of the Class Mammalia, it presents the same character as in Man, but is not so much tinged by the black pigment. In the bird, it presents a rich yellow-brown tint. In fishes, where it has already been incorrectly described by Haller and Cuvier as the medullary layer, it is of a soft, friable, thick, gluey structure. Its inner surface is not tinged with black pigment, but presents

a clear white, not unaptly compared by Haller to snow. Dr Jacob's method of examining these parts is very ingenious. He takes a hollow sphere of glass, about two or three inches in diameter, about one-fourth of which is cut off at the part where it is open, and the edges are ground down, so as to fit accurately upon a piece of plate-glass, the surface of which is also ground. The object to be examined is attached to a piece of wax, fastened upon the plate of glass, and immersed in a basin of water, with the cut sphere, which is inverted over it, of course full of water, and the whole withdrawn from the basin. In this way, the delicate membrane floats in water, and may be unfolded and displayed. By this method, also, a preparation may be handed round a class-room.—See *Phil. Trans.* 1819, part ii. p. 300—307.

43. *Nearest approach to the North Pole.*—In the year 1806, Mr Scoresby, when mate in his father's ship, the Resolution of Whitby, succeeded, after great efforts, and by exposure to imminent hazard, in reaching the latitude 81° 30′, within about 600 miles of the Pole. This took place in longitude 19° East. The nearest approximation to the South Pole has been to the 72d degree, about 1170 miles from the Pole.—See Scoresby's *Account of the Arctic Regions*, vol. i. p. 312.

44. *Method of Blowing up Ice.*—As it is often of great importance to clear rivers and canals, &c. of ice, the following method, which was first suggested and successfully put in practice by Mr John Merricks of Esk-Hill, will be found to be simple and easily executed. A hole having been dug in the ice with a chisel, and a piece of board placed across it, a tin-canister, containing a few ounces of gunpowder, and terminating upwards in a tin tube, is suspended about two feet under the ice, and rests by a shoulder upon the piece of wood. The gunpowder being exploded by a match in the ordinary way, the ice will be blown up in all directions. In one trial, where the ice was 3½ inches thick, the ice was broken through a space 15 yards long and 11 broad. Mr Merricks suggests that this method might be of use in the Greenland Seas, when a vessel is frozen in ice. Mr Scoresby, to whom we communicated this idea, remarks, that he has seen a case, in which a vessel was

frozen in a body of ice, *near an opening of water*, where this method might have been of great use.

45. *On the Production of Potash from Potato Stalks.*—It was lately announced in the philosophical Journals, that in France potash had been obtained in great quantities from potato stalks. In order to put this to the test of experiment, Sir John Hay, Bart. and Dr MacCulloch made a trial on a large scale, and found that the quantity of potash was so small, that no person could be remunerated by it for the trouble of the process. Messrs Taylors of Queensferry, by desire of Sir John Hay, made an experiment on the produce of two acres of potato stalks, which yielded 2 casks of ashes, weighing 2 cwt. 23 lb. which produced of soluble substance only 36 lb. containing a great deal of muriate of potash and sulphate of potash. The value of this produce was not more than 2d. *per* lb. or 6s. in all; and on 12 acres of their own they had a similar result.

46. *Spirits in Glass Jars closed with Bladder, Mode of improving Wines.*—Dr Sommering, in a curious set of experiments detailed in the Memoirs of the Munich Academy of Sciences, has proved, that if mixtures of spirit-of-wine and water in glass jars, are covered, some with bladder, and others with paper, that the aqueous ingredient escapes through the bladder and leaves a concentrated spirit; while, on the contrary, it is the spiritous ingredient which passes through the paper, and leaves little else than water. It is proposed to fine and improve wines by exposing them in vessels covered with bladder or some similar substance. In some experiments made with Cyprus wine, a sixth part escaped, and the wine was very much improved in quality. This mode of improving wines is practised in some parts of Suabia.

47. *Method of rendering Glass less Brittle.*—A method has been published in the foreign journals, for rendering glass less brittle, by heating it in water up to the boiling point, and then allowing it to cool slowly. In order to try this method, we took plates of unannealed glass, the mechanical condition of which was indicated by the tints which they exhibited in polarised light, and we found, that the *mechanical condition of glass, whether annealed or unannealed, was not capable of being altered by the heat of boiling water.* In choosing articles of glass, the

only possible method of ascertaining their quality, is by examining them in polarised light, and rejecting those that exhibit any symptoms of imperfect annealing.—See *Phil. Trans.* 1816.

48. *Humboldt's Journey into India.*—We are informed that the celebrated traveller Humboldt is busily employed in preparing for the press an extensive work on the geology of America, and that he intends leaving France in autumn for Madras, taking the route through Greece and Persia. He will be accompanied by several fellow-travellers, as M. Valencienne, a young zoologist, Künth, his botanical assistant, and others.

49. *Brongniart's Journey.*—M. Brongniart, the distinguished French mineralogist, proposes to leave Paris in spring on a six months geological tour through Switzerland and Italy.

50. *University of Moscow.*—Although the whole buildings of the University of Moscow, with its splendid library and museum, fell a sacrifice to the flames in 1812, when Russia was ravaged by the French army, yet, through the activity of the Government, aided by the munificence of the Emperor Alexander, the whole has been rebuilt. The Museum of Natural History is already very extensive; and the Emperor has purchased for £6000 the famous anatomical collection of the celebrated Loder, formerly Professor of Anatomy at Jena, but now called to Moscow. Dr G. F. Hoffmann, the well known botanist, and formerly Professor of Botany at Göttingen, has accepted the liberal offers of the Emperor, and is now Professor of Botany, and Superintendant of the Botanical Garden at Moscow. The natural History department is under the direction of Dr F. Fischer, a distinguished naturalist, and well known to the scientific world by his numerous works in different branches of natural history.

51. *Birds of Paradise.*—Temminik, the celebrated Dutch ornithologist, is about to send a naturalist to the Indian Islands, at his own expence, whose principal object will be the investigation of the natural history and physical distribution of the Birds of Paradise, the Paradisea of Linnæus.

52. *Translation of Livy and Ovid into the Russian Language.*—At the last general meeting of the Imperial Academy

of Sciences of Petersburgh, M. Sokolow presented a part of his translation into Russian of Livy; Mr Schukowsky, a fragment of his Russian translation of Ovid; and M. Von Karamsin, the ninth part of his History of the Russian Empire.

53. *Jameson's Elementary Work on Geognosy.*—This work, we understand, will be published early in the ensuing summer.

54. *Wernerian Memoirs.*—The third volume of the Memoirs of the Wernerian Natural History Society will probably appear next month.

55. *Edinburgh Transactions.*—The first part of vol. IX. of the Transactions of the Royal Society of Edinburgh will be published in a few weeks.

56. *Griffith's Geological Surveys in Ireland.*—We have lately seen Mr Griffith's Survey of the Connaught coal district, but delay speaking of it, until we have an opportunity of procuring Mr Griffith's other mineralogical writings, and those also of Weaver, when we shall give an account of the labours of these gentlemen, and of the present state of Geology in Ireland.

57. *Mr Watt and M. Prony.*—We have observed, with deep regret, an article in the *Phil. Mag.* containing the most unjust aspersions on the character of M Prony, in relation to his writings respecting the steam-engine. Discussions of this kind we have a particular wish to avoid; but it is only because we possess particular information on the subject in question, that we feel it a duty to rescue a distinguished name from calumnies, which do more discredit to the country in which they are tolerated, than to the person whom they are intended to injure. During the last ten years of Mr Watt's life, the writer of this notice enjoyed many opportunities of conversing with him respecting the history of the steam-engine; and he can confidently state, that Mr Watt considered M. Prony as having committed only a trifling mistake, in stating that Mr Watt's invention, called the *Parallel Motion*, originated in Suardi's pen. When the writer of this notice went to Paris, in 1814, he received from Mr Watt a letter of introduction to M. Prony, whom Mr Watt considered as one of his most sincere and valuable friends.

Art. XXXV.—*List of Patents granted in Scotland since* 10*th December* 1819.

26. To Francis Fox the younger, of Derby, in the county of Derby, Doctor in physic, for his invention of "a new or improved method of facilitating the discharge of fire-arms and artillery of every description." Sealed at Edinburgh 15th December 1819.

1. To James Dickson, lapidary, Gilmore Place, Edinburgh, for his invention of "an improvement or improvements in communicating power to machinery by water, spirits-of-wine, quicksilver, oil, or fluids, which improvement or improvements are applicable to other purposes." Sealed at Edinburgh 15th January 1820.

2. To Louis Fauche Borel of the Haymarket, in the parish of St Martin in the Fields, gentleman, in consequence of a communication from certain foreigners residing abroad, for an invention called "The moveable and inodorous conveniences." Sealed at Edinburgh 9th February 1820.

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